OXO-BIODEGRADABLE PLASTICS ASSOCIATION

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BRIEFING NOTE on BIODEGRADABLE PLASTICS

(NB. check at http://www.biodeg.org/briefing-note/ that you have the latest edition)

The Oxo-biodegradable Plastics Association exists to provide information to encourage greater understanding of oxo-biodegradable plastic technology and the role it can play in protecting the environment for future generations. Members are manufacturers, suppliers, distributors, and commercial end-users of oxo-biodegradable plastic, and there are now 87 members in 72 countries. The Association is proud to have on its Scientific Advisory Board some of the world's most distinguished polymer scientists.

EXECUTIVE SUMMARY

In no country in the world is it possible to collect all the plastic waste. Some of it will always escape accidentally or deliberately into the environment where it could lie or float around for decades. Oxo-biodegradable plastics ("oxo-bio") are intended as low-cost insurance against this form of pollution, but degradability is not intended as a disposal route.

Global production and consumption of plastics increased from 5 million tonnes in 1950 to 245 million tones in 2006.[5] Recent surveys show that consumers believe that packaging is the top environmental problem in relation to the products they buy. Less packaging, and more recyclable, recycled or biodegradable packaging came at the top of their wish list.[6]

The EU Commissioner for the Environment pointed out that "The longevity of plastic bags means that there are now some 250 billion plastic particles with a combined weight of 500 tonnes floating in the Mediterranean Sea alone.[7]"

We have all heard of the massive patch of plastic waste floating in the Pacific Ocean. What supermarket director wants his or her grandchildren to find on a beach a plastic bag with their company's name on it, which has been floating around the oceans for 50 years or more?

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5 Plastics Europe, The Compelling Facts About Plastics – An analysis of plastics production, demand and recovery for 2006 in Europe, January 2008
6 http://www.defra.gov.uk/environment/waste/strategy/factsheets/packaging.htm
7 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/11/580&format=HTML&aged=0&language=EN&guiLanguage=en

Plastic, like almost everything in the natural world, will eventually degrade and be bioassimilated, but the plastics industry has been so successful that it has created plastics which will last for decades. There is therefore mounting public concern about the longevity of plastic which gets into the rivers, oceans and landscape and cannot realistically be collected for disposal. For this reason the plastics industry is under attack somewhere in the world almost every day.

On 18th July 2008 Dr Caroline Jackson MEP[8] issued a press statement as follows:

"European legislation on waste has tended to concentrate on waste which can be collected, and to encourage people to reduce, re-use, and dispose responsibly of their waste, by recycling, incineration with energy-recovery, or by other disposal routes."

"However, we also need to take account of the fact that there we will never succeed in collecting all the waste and that some may remain to disfigure the landscape. This is particularly the case with plastic waste, from errant supermarket bags to agricultural plastic. Where this goes uncollected it can accumulate in the environment, polluting the land and the oceans for many decades, and perhaps for hundreds of years."

"Technologies have now become available which can produce plastic products such as shopping bags, garbage sacks, packaging etc. which are fit for purpose, but will harmlessly degrade at the end of their useful life. These fall into two broad categories, namely:

1. Hydro-biodegradable plastics, made wholly or partly from crops, which biodegrade in a highly microbial environment, such as composting, and
2. Oxo-biodegradable plastics, made from a by-product of oil-refining, which degrade in the environment by a process of oxidation initiated by an additive formulation, and then biodegrade after their molecular weight has reduced to the point where naturally-occurring micro-organisms can access the material."

"We need to encourage both of these technologies, and to ensure that European Standards are developed which are appropriate to both. It is worth bearing in mind that the Parliament is concerned by the use of scarce land and water resources around the world to produce biofuels in competition with food-crops and the same concern applies to growing crops to make biodegradable plastics, so I hope the European Commission will give more positive support to oxo-bio plastics."

For the first time the EU commission have expressly recognised the problem of plastic litter in the environment, which d2w is designed to address. In their May 2011 Consultation Document on Plastics Bags[9] the Commission said:

“Plastic carrier bags are packaging products with a short lifespan that due to their low weight and small size, can easily escape the waste management flows and be conveyed to the sea by rain, drains and rivers. Once in the environment, plastic bags can last for hundreds of years. Because they last so long, every year the number of plastic bags in the litter stream increases. “

The Commission also said “In the current practice, a packaging product is acknowledged to be biodegradable if it biodegrades in industrial composting facilities in controlled conditions. However, a product that is compostable in an industrial facility will not necessarily biodegrade in natural conditions in the environment.”

8 Dr. Jackson is a former Chairman of the Environment, Public Health, and Food Safety Committee of the European Parliament, and was the Rapporteur for the EU Waste Framework Directive. See also www.packagingnews.co.uk/News/833174/MEP-Jackson-calls-EC-support-hydro-oxo-biodegradable-plastics/

9 17th May 2011 http://ec.europa.eu/yourvoice/ipm/forms/dispatch?form=PLASTICBAGS

The Commission made the important point that "Advertising a packaging product as biodegradable when in fact it will not biodegrade in natural conditions can be misleading for the consumer and can contribute to the proliferation of littering of products that will persist in the environment." This Association therefore expects that suppliers of compostable plastic will stop describing their product as "biodegradable."

The Commission also said "The current legislative provisions do not allow for a clear distinction between biodegradability and compostability" - highlighting the need for a Standard in Europe for oxo-biodegradable plastic, which has now been published as British Standard 8472.

The fundamental point about oxo-biodegradable technology is that the additive included at manufacture causes ordinary plastic to quickly convert at the end of its useful life in the presence of oxygen into a material with a different molecular structure. At that stage it is no longer a plastic and has become a material which is inherently biodegradable in the open environment in the same way as a leaf. It therefore simulates the way nature disposes of wastes such as twigs and straw, but much more quickly than many, notably wood (lignocellulose) residues.

Approximate timescale for degradation can be set at manufacture as required. For a video of plastic film degrading, go to: http://degradable.net/play-videos/4

Oxo-degradation is defined by CEN (the European Standards Organisation) in TR15351 as "degradation resulting from oxidative cleavage of macromolecules." And oxo-biodegradation as "degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively."

Oxo-biodegradable plastics approved by this Association do not contain organo-chlorine, nor PCBs nor "heavy metals" and they are safe for direct food contact. They leave NO fragments, and they are required to pass the ecotoxicity tests in BS8472, ASTM D6954 and EN13432 so as to ensure that there are no toxic residues.

The British Plastics Federation presented to the UK Government on 21st April 2011 a detailed scientific response to the Loughborough Report on Oxo-biodegradable (OBD) Plastics published by DEFRA in March 2010. This response provides DEFRA with evidence, both from peer-reviewed academic literature and from studies in independent laboratories (both appended to the report), which proves that:

- Properly formulated OBD plastic films can be made to degrade oxidatively at ambient temperature in short (< 1year) periods to materials whose molecular weights and polarities are such as to make them biodegradable.
- Oxidative degradation in biologically-active environments is faster than in the typical air-oven conditions used for laboratory investigations, so that laboratory testing over-, rather than under-estimates lifetime in the environment.
- Properly formulated OBD plastic films, once oxidatively degraded can be shown to mineralise to CO2 and H2O in soil contact; greater than 90% mineralisation has been demonstrated in independent laboratory testing.
- There is no evidence of any ecotoxicity from OBD plastics at any stage of their degradation, and a great deal of detailed evidence that there are no ecotoxicity implications to their use.
- Claims of accumulation of undegraded or partially degraded plastics in the environment are wholly unjustified.
- OBD plastics will not compromise an oil-based recycling stream.

In the intermediate phase of the degradation of all plastics (including “compostable” plastics), fragments are created, but there is no evidence that they attract toxins or behave generally in the environment in a way which is materially different to fragments of partly-degraded leaves or seaweed. In the case of oxo-biodegradable plastics the molecular weight of the fragments get smaller and smaller until there is nothing left except naturally-occurring materials such as hydro-peroxides, which are rapidly scavenged by micro-organisms. Using the test methods prescribed by BS 8472, American Standard D6954-04 and EN 13432 it has been shown that oxo-bio is not eco-toxic.

It is sometimes argued that BS 8472 and ASTM D6954 are not Standards, and that they prescribe test methods without setting a pass/fail test. In fact ASTM D6954, written and published by ASTM International (the US Standards body) is certainly an acknowledged standard. It not only provides detailed test methods but it also provides pass/fail criteria. For example para. 6.6.1 requires that 60 % of the organic carbon must be converted to carbon dioxide prior to ending the test. Similarly BS8472 provides that at least 50% carbon evolution must be demonstrated during the test.

See also a statement on oxo-biodegradable plastics by the respected laboratory Smithers-RAPRA.[10]

It is not possible to prescribe a timescale in a general standard for oxo-biodegradable plastic, (as distinct from compostable plastic) because the conditions found in industrial composting are specific and the conditions found in the open environment are variable. Moreover, the time taken for oxo-biodegradable plastic to commence and complete the processes of degradation and biodegradation is also variable.

In particular, an oxo-biodegradable plastic product can be designed to commence the degradation phase at a pre-determined time, which is not possible with compostable plastics. For example, a bread wrapper may be designed for a service life as short 6 months, though some bakeries may specify a longer period. A plastic shopping bag could have a service life of 18 months before degradation starts, and a durable shopping bag as much as 5 years. Accordingly a “one size fits all” timescale set in a general Standard is wholly inappropriate.

The question whether the sample has “passed” or “failed” the tests depends upon the report required by the Standards. If the report shows that the material has biodegraded to a degree and within a timescale acceptable to the customer (or to the government in countries with relevant legislation), and that it is not toxic, it has passed – otherwise it has failed.

There is no requirement in an oxo-biodegradable Standard for 90% to be converted in 180 days because while timescale is critical in an industrial composting process, it is not critical for biodegradation in the environment, and such a short timescale is actually undesirable. The requirement in EN13432 and similar standards for 90% conversion to CO_2 gas within 180 days is not useful even for composting, because it contributes to global climate change instead of contributing to the fertility of the soil.

Oxo-bio is made from a by-product of oil or natural gas, so nobody is importing or extracting extra oil and gas to make it. In fact plastics could reduce the amount of oil and gas imported because after their useful life they can be incinerated to release the energy stored in the plastic, which can be used to generate electricity or to heat buildings.

[10] 10 http://www.rapra.net/consultancy/biodegradable-plastic.asp

There is little or no additional cost to oxo-biodegradable plastic, because it is made with the same machines and workforce as ordinary plastics, and uses substantially the same low-cost raw materials.

Oxo-bio plastic is NOT currently marketed as compostable, and biodegradation in the environment is NOT the same thing as composting.

Industrial composting is an artificial process operated according to a much shorter timescale than the processes of nature. Standards (such as ASTM D6400, D6868, EN13432, ISO 17088 and Australian Standard 4736-06) designed for compostable plastic should not therefore be used for plastic which is designed to self-destruct if it gets into the environment. Indeed EN13432 itself says that is not appropriate for waste which may end up in the environment through uncontrolled means.

Composting of organic waste makes sense, but hydro-biodegradable compostable plastic for shopping bags, food packaging, shrink-wrap etc. does not. It is up to 400% more expensive than ordinary plastic; it is thicker and heavier and requires more trucks to transport it; recycling with oil-based plastics is impossible; it uses scarce land and water resources to produce the raw material, and substantial amounts of non-renewable hydro-carbons are burned and CO_2 emitted, by the tractors and other machines employed. If buried in landfill, hydro-biodegradable plastics can emit methane (a greenhouse gas 23 times more powerful than CO_2) in anaerobic conditions.

A report from N Carolina State University published[11] in May 2011 in "Environmental Science & Technology" has found that hydro-biodegradable plastics (described as biodegradable plastics) emit undesirable amounts of greenhouse gas at a rapid rate in landfill.

Methane gas emissions from closed and operational landfill sites contribute to an estimated 3% of the UK's total greenhouse gas emissions[12]

In February 2011 a Life Cycle Assessment[13] was published by the UK Environment Agency which shows that oxo-biodegradable plastic bags have a better LCA than paper bags or compostable plastic bags.

In June 2009 a Life-cycle Assessment[14] was published by Germany's Institute for Energy and Environmental Research (IFEU), which concluded that polyethylene sacks made from Post Consumer Recyclate have generally the smallest environmental impact profiles and can be considered the most "eco-friendly" materials for waste bags; provided the bags can be made and also perform (i.e. are technically fit for purpose) at thicknesses similar to those made from virgin materials. (Oxo-biodegradable garbage sacks are made from polyethylene and can be either recycled or virgin material).

They added that "The current bags made from bioplastics have less favourable environmental impact profiles than the other materials examined" and that this is due to the process of raw-material production.

Scientific research published in the International Journal of Life Cycle Assessment[15] concludes that bio-based plastics are not sustainable. "Although bio-based products

[11] http://pubs.acs.org/doi/pdfplus/10.1021/es200721s

[12] (http://www.environment-agency.gov.uk/news/114383.aspx?month=12&year=2009&sector=Waste&persona=Science

[13] http://degradable.net/files/uploaded/Carrier_Bags_Report_EA.pdf

[14] http://www.kunststoffverpackungen.de/en/news/LCA%20waste%20bags%20-%20Study%20Extract%20B.pdf

[15] Vol: 15, 284-293 (2010)

have been mostly regarded as a sustainable solution for replacing petroleum-based polymers, in most cases, the amounts of resources and energy required to produce them have not been taken into account. Before bio-based plastics can be recommended as a preferred option to plastics, a few challenges have to be overcome. One of the main concerns is reducing the energy used in the life cycle production of the bio-material from crops."

The packaging technical manager of Tesco (Britain's largest supermarket) said on 20th October 2009 that the supermarket "does not see the value in packaging that can only be industrially composted" and that "local authorities do not want to touch it, as it can contaminate existing recycling schemes." A few days earlier, Tesco's head of waste and recycling had told a conference that the supermarket group was "not taking compostable packaging any further."

Many industrial composters of organic waste around the world do not want plastic of any kind in their feedstock, (unless they are running a special collection programme) because it is difficult to separate biodegradable plastic from ordinary plastic.

Oxo-bio plastic is NOT intended to degrade deep in a landfill, but if it is landfilled the process of oxo-degradation shuts down under anaerobic conditions (see below).

Oxo-bio plastic can be recycled in the same way as ordinary plastic (see www.biodeg.org/recycling.htm) and does not need special collection points.
Recycled plastics are good, and this Association supports the recycling industry, but they are not degradable and will still lie around in the open environment for decades. However, ordinary plastic and recycled plastic can now be made oxo-biodegradable.

The Advertising Standards Authority of South Africa ruled on 8th April 2010[16] that bread bags made with oxo-biodegradable plastic can be advertised as Biodegradable. The Directorate of the ASA considered the expert evidence, and rejected a complaint against Tiger Brands. They said that they were "satisfied that their Albany bread bags have been shown to be biodegradable."

TIMESCALES FOR DEGRADATION

It is important to remember that there are four phases to the life of an oxo-biodegradable plastic product.

1. Shelf-life
2. Service-life
3. Oxidation and Disintegration
4. Biodegradation

1. Shelf-life

When oxo-biodegradable plastic products are made, they will usually be packed in a cardboard, plastic or other opaque packaging and therefore shielded from ultra-violet light and with very little or no access to oxygen. Whilst they remain in this packaging at normal room temperatures or below, no significant degradation will occur.

2. Service-life

After removal from their packaging, the oxo-biodegradable products need to have a service-life during which they are in all respects fit for purpose. The length of the

[16] http://www.asasa.org.za/ResultDetail.aspx?Ruling=5108

service-life is decided by the commercial end-user. Service-life is determined by the formulation within the additive (not the amount of the additive), for the particular resin package, and the additive-supplier adjusts the formulation accordingly.

Typically, supermarkets expect a combined shelf-life and service-life for a carrier-bag of about 18 months, because they have to keep stocks, and wish to encourage customers to re-use many times for shopping and other purposes before final disposal. Carrier bags are not "single-use" bags. For a bread-wrapper a shorter combined shelf-life and service-life of about 6 months, could be specified, though some may request a longer period.

If collected during phase 1 or 2 the product may be safely recycled with ordinary plastic http://www.biodeg.org/position-papers/recycling/?domain=biodeg.org

3. Oxidation and Disintegration

At the end of the service-life of the product the pro-degradant additive causes the molecular chains within the polymer to break down. This is done by a process of oxidation and will therefore occur only if oxygen is present. It can occur in the open environment or in the upper layers of a landfill, but deeper down in a landfill, if conditions are anaerobic, the process stops and the undegraded material will not emit methane. This is important because methane is a greenhouse gas 23 times more powerful than CO2. By contrast hydro-biodegradable plastics (usually bio-based and marketed as compostable) do emit methane in anaerobic conditions.

The oxidation phase is purely abiotic and does not depend on bacteria or other micro-organisms, nor is moisture necessary. As oxidation proceeds the molecular-weight of the polymer decreases rapidly from 250,000 Daltons or thereabouts to an average of 40,000 when it no longer has the physical properties of a commercial polymer. The average molecular-weight continues to descend to 5,000 or less.

The molecular structure is then completely different and it has even at 40,000 already been converted to inherently biodegradable low molecular-weight materials such as aldehydes, alkenes, ketones, alcohols, ethers, esters, and peroxides, which are similar or in most cases identical to those formed during bio-degradation of natural materials. The fragments resulting from the oxidation process will stick to soil particles and will not be easily wind-borne, as they are hydrophilic compared to the original polymer which is hydro-phobic.

The process requires only oxygen. It does not need sunlight or elevated temperatures, but these will synergistically accelerate the process. The time taken to reduce to an average value of 5,000 Daltons depends on the amount and intensity of heat and/or light, but would normally be less than 6 months from commencement of oxidation in the open environment in temperate climates. In warmer climates it would be faster and in arctic conditions slower.

This is the timescale on which legislators need to focus, because the material will then be no longer a plastic; it will have lost its strength and will be no longer capable of entangling wildlife or blocking drains. It will not by that time be visually intrusive, and it is not toxic. Testing of oxo-biodegradable plastics includes a standard OECD test to demonstrate non eco-toxicity.

4. Biodegradation

At the end of the oxidation phase the biodegradation phase begins, and it may be partly concurrent with the oxidation phase. It is not necessary for the material to be composted, and biodegradation will continue in normal environmental conditions until about 90% biodegradation has been achieved. The remaining 10% is transformed into harmless biomass through microbial activity.

Accordingly, the time taken for the biodegradation phase to be completed is not important. A leaf could take many years, and ASTM D6954 allows a combined

oxidation/biodegradation period of two years for 60% of a single oxo-biodegradable polymer to convert to CO_2. BS8472 does not impose a time limit at all.

It is not in fact necessary to repeatedly perform expensive and very time-consuming carbon-evolution tests to demonstrate biodegradation if it has been established by GPC tests according to ASTM D6474-99 that the material has descended to 5,000 Daltons or less, as described above. The fragments then include oxygen as organic functional-groups.

The Standards for compostable plastic such as ASTM D6400, EN13432, Australian 4736, ISO 17088 etc. require the material to convert itself substantially into CO_2 gas within 6 months. This is the timescale required by industrial composters, for whom time is money, but such a short timescale is not necessary for oxo-biodegradable plastic, which is designed to biodegrade in the open environment. Nor is a high rate of conversion desirable, because conversion to CO_2 gas contributes to climate-change and depletes the carbon available for the soil.

DIFFERENT TYPES OF BIODEGRADABLE PLASTIC

It is essential to distinguish between the different types of biodegradable plastic, as their costs and uses are very different

In the case of both oxo-biodegradable and hydro-biodegradable, degradation begins with an abiotic process (oxidation and hydrolysis respectively), followed by bioassimilation of the breakdown products. Both types emit CO_2 as they degrade, which is absorbed by plants, but hydro-biodegradable can also emit methane. Hydro-biodegradable is much more expensive than oxo-biodegradable, and only oxo-biodegradable can be recycled in a normal waste-stream.

A. OXO-BIODEGRADABLE PLASTIC

This technology produces plastic products which degrade by a process of OXO-degradation, caused by a very small amount of a pro-degradant formulation[17], being introduced into the manufacturing process of the product. Degradation begins when the programmed-service life is over (as controlled by the stabilisers within the formulation) and the product is no longer required.

In the first phase of the degradation process the formulation breaks the molecular chains so that the material can no longer be considered a plastic but a material with an entirely different molecular structure. The material does not just fragment, but will be consumed in the second phase by bacteria and fungi[18] after the formulation has reduced the molecular weight to a level[19] which permits living micro-organisms access to the carbon and hydrogen. It is therefore “biodegradable.” [20] This process continues until the material has biodegraded to nothing more than CO_2, water, and humus, and **it does not leave fragments of petro-polymers**. The CO_2 will be absorbed by plants.

Oxo-biodegradable plastics degrade, then biodegrade, on land or at sea, in the light or the dark, in heat or cold, in whatever timescale is required, leaving NO fragments and NO harmful residues.

17 Members of this Association use formulations based on salts of manganese or iron

18 “Degradable Polymers – Principles and Applications” Kluwer Academic Publishers 2002 Chapt 3; "Environmental biodegradation of polyethylene", S.Bonhomme, A. Cuer, A-M.,Delort, J. Lemaire, M.Sancelme and G.Scott, Polym. Deg. Stab., 81, 441-452

19 sub 40,000 Daltons

20 Oxo-degradation is defined by CEN (the European Standards Organisation) in TR15351as “degradation resulting from oxidative cleavage of macromolecules.” And oxo-biodegradation as “degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively.”

In Europe and Asia polymers are normally made from naphtha, which is a by-product of oil which used to be wasted. In the United States polyethylene is made of ethylene which is extracted from natural gas.

Using the naphtha or ethane to make plastic does not reduce the amount of fuel available for transport or power-generation nor increase energy extraction or imports. In fact plastics could reduce the amount of oil and gas imported because after their useful life they can be incinerated to release the stored energy, which can be used to generate electricity or to heat buildings.

Degradation and biodegradation of an oxo-biodegradable polyethylene specimen consistent with changes expected by Tiers 1 and 2 of ASTM D 6954-04 has been found by RAPRA[21] Oxo-biodegradable additive also passes eco-toxicity tests prescribed by Tier 3 of ASTM D 6954-04[22]

There is little or no additional cost involved in products made with this technology, as they can be made with the same machinery and workforce as normal commercial plastics, and with the same low-cost polymers.

In rivers, lakes and oceans most oxo-biodegradable polyethylene films float on the surface, where they are oxidised with consequent fragmentation and biodegradation. There is oxygen and ultraviolet light on the surface, there are sufficient micro-organisms, and the wind and waves subject the material to stress. Even if the material sinks, and uv light is reduced, degradation will continue while oxygen is present. There are normally enough micro-organisms, and there may also be stress caused by sub-surface currents.

Specimens of oxo-biodegradable LDPE (low-density polyethylene) and PP (polypropylene)[23] and PS (polystyrene)[24] have been tested and demonstrated under the conditions of test to be fully compliant with the current European food contact material requirements.[25] Oxo-biodegradable additives approved by the Oxo-biodegradable Plastics Association have also been certified as compliant with US Food & Drugs Administration requirements[26].

Unlike PVC, the polymers from which oxo-biodegradable plastics are made do not contain organo-chlorine. Nor do oxo-biodegradable polymers contain PCBs, nor do they emit nitrous oxide - even under anaerobic conditions.

Oxo-biodegradable bags are being bought and distributed by supermarkets worldwide, and used for direct contact with food products. [27] Oxo-biodegradable plastic is ideal for frozen food packaging, as it can be kept for extended periods at low temperature, and will then quickly degrade abiotically in the environment when it becomes a waste product at normal temperatures.

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[21] Tier 1 (Degradability) test 46023 20th March 2006. Tier 2 - (Biodegradability) test 46303 7th June 2006. RAPRA Technology Analytical Laboratories are accredited by the United Kingdom accreditation authorities as meeting the requirements of International Standards Organisation norm no.17025

[22] Reports 1812/93224 8th Mar 2006. See also Prof. G. Scott and others, *Degradable Polymers: Principles and Applications*, Kluwer, 2002, Chapter 13, Section 9.11, page 472, et seq.

[23] RAPRA report 19th March 2007. RAPRA Technology Analytical Laboratories are accredited by the United Kingdom accreditation authorities as meeting the requirements of International Standards Organisation norm no.17025.

24 RAPRA report 12th April 2005

25 European Directive 2002/72/EC (as amended 2004/19/EC).

26 RAPRA confirmation 14th November 2007. Keller & Heckman certificate 18th February 2009

[27] In September 2007 the Commercial Packaging Manager of the Co-op said "I am happy to say that we are using Oxobiodegradable polythene films for direct food contact applications. We currently use these materials for pre-packed produce, self serve produce, pre-packed bread, frozen vegetables and fresh turkeys as well as for carrier bags. The approval for use has been based on the very strict EU requirements under EU Directives 2002/72/EC and 2004/19/EC relating to plastic materials and articles intended to come into contact with foodstuffs. We have been using these materials for food contact use since 2004."

Oxo-biodegradable plastic products are now being used by leading UK supermarkets. In Portugal the country's largest retail group, Sonae, has adopted oxo-biodegradable plastic for their Continent, Mondelo and Mondelo Bonjour supermarket chains. Other users include TigerBrands South Africa, the Inditex Group[28] (owners of Zara), the Bimbo Group of Bakeries in Latin America, Marriott Hotels, BUPA Care Homes, Subway fast food chain, News International, Pizza Hut, KFC, French Railways, The Brazilian Post Office, Barclays Bank, and Walmart (Argentina).

In May 2007 the Periodical Publishers Association of the UK[29] recommended to all its members that oxo-biodegradable film should be used for wrapping their newspapers and magazines for distribution.

The length of time it takes for oxo-biodegradable products to degrade can be 'programmed' at the time of manufacture and can be as little as a few months or as much as a few years. They are protected from degradation by special antioxidants until ready for use, and storage-life will be extended if the products are kept in cool, dark conditions.

One company is able to make plastic carrier bags which will self-destruct within a few weeks of being taken by a customer out of the supermarket.

Fossil Resources

Plastics are currently made from by-products of oil or natural gas. These by-products arise because the world needs fuels and would arise whether or not the by-products were used to make plastic goods. So, nobody is extracting or importing extra oil or gas to make plastic. Until other fuels and lubricants have been developed it makes good environmental sense to use this by-product instead of using scarce water and agricultural resources to make vegetable-based plastics, jute, cotton or paper. In fact plastics could reduce the amount of oil and gas imported because after their useful life they can be incinerated to release the stored energy, which can be used to generate electricity or to heat buildings.

A Life Cycle Assessment was carried out in January 2005 by GUA – (Gesellschaft für umfassende Analysen) of Vienna which shows that:

"Plastic products are made of energy resources. Additionally, their production needs further energy resources. Nevertheless, plastic products frequently enable energy *savings* from the perspective of the energy balance of the total life cycle compared to the energy balance of an alternative material. Examples for such energy savings by plastic products are:

• Substitution of materials which consume much more energy for production of the same functional unit (e.g. glass)
• Performance of a certain function with much less material (e.g. packaging)
• Fuel savings because of reduction in mass (transport)
• Energy savings due to thermal insulation (where insulation with other materials would be less effective, technically complicated or too expensive)
• Savings of resources by avoiding loss or damage of packed products."

Fossil-fuel use in the manufacture of 1,000 paper bags composed of at least 30% recycled fibre is 23.2 kg, 41.5 kg for 1,500 compostable plastic bags and only 14.9 kg for 1,500 ordinary PE plastic bags.[30]

28 See 2007 Annual Report page 163
http://www.inditex.com/en/shareholders_and_investors/investor_relations/annual_reports
29 www.ppa.co.uk/cgi-bin/go.pl/news/article.html?uid=11657
30 Boustead Assoc (2007)

Recently, interest has been shown in manufacturing sugar-derived polyethylenes. These, like fossil-derived PE, are not biodegradable, but they can be made oxo-biodegradable in the same way, by the addition of a pro-degradant formulation.

Deliberately and totally lost?

The argument that biodegradable plastics are undesirable because their components are designed to be deliberately and totally lost is certainly true of hydro-biodegradable or "compostable" plastics. This is because, as indicated above, they cannot comply with EN13432, ASTM D6400, ISO17088, Australian Standard 4736-06 and similar standards unless 90% of the material converts to CO_2 gas within 180 days or less.

However, this criticism is not true of oxo-biodegradable plastics products. If people want to recycle them, or re-use them during their useful life (usually at least 18 months), then that is practicable, and they cost very little if anything more than conventional products.

The key point is what happens to the plastic which is *not* collected, and gets into the environment.

Oxo-biodegradability is not a disposal option. It is a low-cost insurance against the accumulation of plastic waste in the environment.

In any event Oxo-biodegradable plastics are not "deliberately and totally lost" even if they degrade in the environment, because biodegradation on land is a source of plant nutrients, just as straw, grass, leaves etc. They do not convert to CO_2 gas within a short timescale.

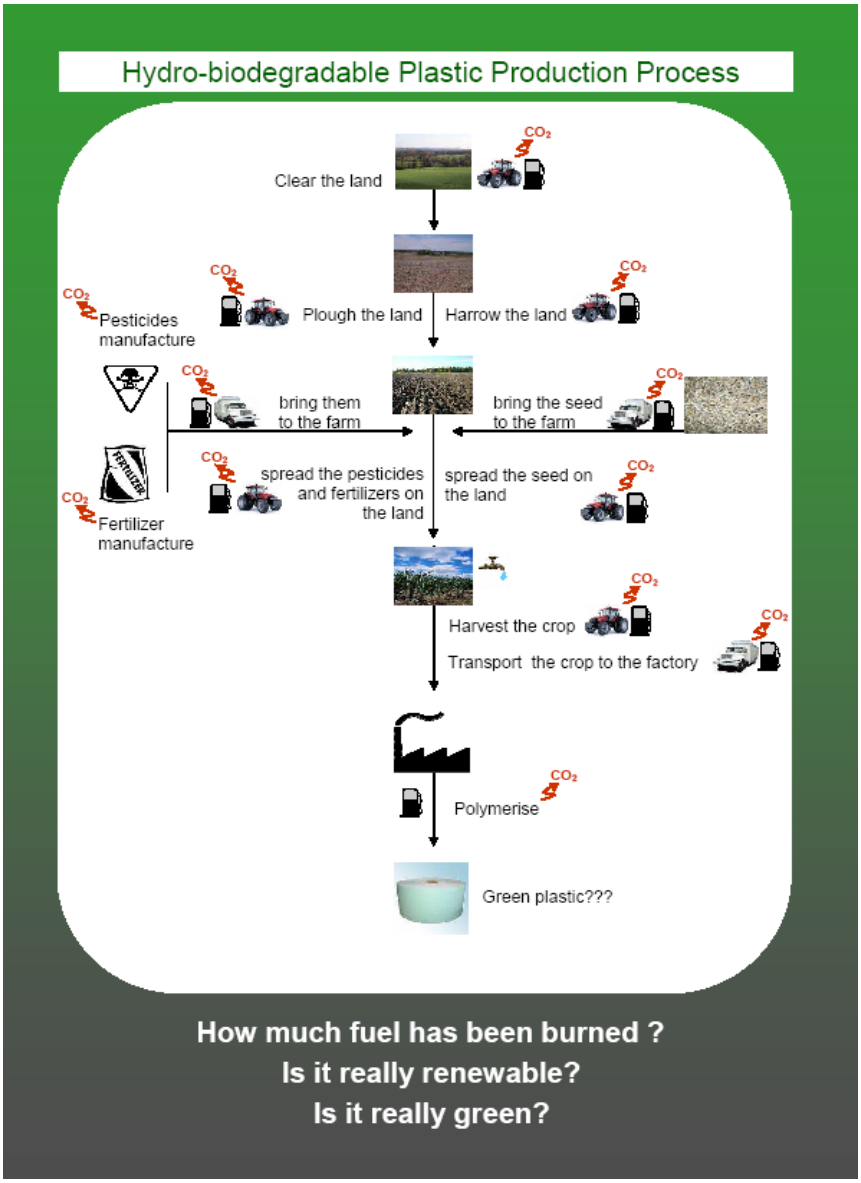
B. HYDRO-BIODEGRADABLE ("COMPOSTABLE" or "BIO-BASED") PLASTICS

These are usually made from crops, and are marketed as "compostable," although thick cross-section products, over 150 microns, will usually fail to meet the composting standards.

Hydro-biodegradation is initiated by hydrolysis, and there is concern that exposure to the sun will cause some hydro-biodegradable plastics to form cross-links which will inhibit biodegradation.

Some plastics in this category have a high starch content and it is sometimes said that this justifies the claim that they are made from renewable resources. However, many of them contain up to 50% of synthetic plastic derived from oil, and others (e.g. some aliphatic polyesters) are entirely based on oil-derived intermediates. Genetically-modified crops may also have been used in the manufacture of hydro-biodegradable plastics.

Hydro-biodegradable plastics are not genuinely "renewable" because the process of making them from crops is itself a significant user of non-renewable fossil-fuel energy and a producer therefore of greenhouse gases. Fossil fuels are burned by the agricultural machinery and road vehicles employed; also by the manufacture and transport of fertilisers and pesticides. Electrical energy derived from fossil fuel is also consumed by the autoclaves which ferment and polymerise material synthesised from biochemically produced intermediates (e.g. polylactic acid from carbohydrates etc). They are sometimes described as made from "non-food" crops, but are in fact usually made from food crops.



In February 2011 a Life Cycle Assessment[31] was published by the UK Environment Agency which shows that oxo-biodegradable plastic bags have a better LCA than paper bags or compostable plastic bags.

In June 2009 a study was published[32] by Germany's Institute for Energy and Environmental Research (IFEU), which concluded that "The current bags made from bioplastics have less favourable environmental impact profiles than the other materials examined" and that this is due to the process of raw-material production.

A disproportionate amount of land would be required to produce sufficient raw material to replace conventional plastic products, and a huge amount of water, which is in such short supply in so many parts of the world.

Residues from some native starches can be seriously toxic; bitter cassava for example (tapioca) has a high level of hydro-cyanic glucoside present, which has to

[31] http://degradable.net/files/uploaded/Carrier_Bags_Report_EA.pdf

[32] (http://www.kunststoffverpackungen.de/en/news/LCA%20waste%20bags%20-%20Study%20Extract%20B.pdf)

be removed by careful washing. During growth the plant is toxic to wildlife. Cassava is exhaustive of potash[33].

There is concern that during the first 90 days of degradation some types of bio-based plastic will be eco-toxic.

Three recent articles in the international press have drawn attention to the danger of using "renewable" resources derived from plants as a substitute for petroleum products. They focus on the use of corn and palm oil to make "biofuels" for motor vehicles, but the same danger arises from the use of corn and other agricultural products to make hydro-biodegradable plastics.

The International Herald Tribune wrote on 31st January 2007 *"Just a few years ago politicians and green groups in the Netherlands were thrilled by the country's adoption of "sustainable energy" by coaxing electricity plants to use biofuel. Spurred by government subsidies, energy companies designed generators that ran exclusively on this fuel, which in theory would be cleaner than fossil fuels because it is derived from plants.*

But last year, when scientists studied plantations in Indonesia and Malaysia, this green fairy-tale began to look more like an environmental nightmare. Rising demand for palm oil in Europe caused the razing of huge tracts of southeast Asian rain forests, and the over-use of chemical fertilisers there. Worse still, space for the plantations was often created by draining and burning peat land, which sent huge carbon emissions into the atmosphere.

In Mexico on 25th January the **financial newspaper "24 ORE"** asked *"Food or fuel? Is maize better on the table as tortillas or in the tanks of cars, converted into ethanol and then bio-fuel? The price of the cereal has doubled in a year because of the high demand for ethanol obtained from maize to produce bio-fuels. It has created a real food crisis because the price of tortillas has increased greatly. They used to cost seven pesos per kilo but now exceed 18 pesos. Tortillas are the basic element of the Mexican diet.*

According to the Earth Policy Institute, "The trade off between food and fuel risks creating chaos in the world market of food products" and they predict that shortages and higher food prices will lead to starvation and urban riots

Business Week 5 Feb 2007 edition *"The rise in the price of corn that's hurting US pig farmers isn't caused by any big dip in the overall supply. In the U.S., last year's harvest was 10.5 billion bushels, the third-largest crop ever. But instead of going into the mouths of pigs or cattle or people, an increasing slice is being transformed into fuel for cars. The roughly 5 billion gallons of ethanol made in 2006 by 112 U.S. plants consumed nearly one-fifth of the corn crop." US chicken producers are also being hit. The industry's feed costs are already up $1.5 billion per year. Ultimately, these increases will be passed on to consumers, and there could be dramatic inflation in food costs.*

The UK House of Commons Environmental Audit Committee has found[34] *that "the stimulation of biofuels production by the [UK] Government and EU is reckless in the absence of effective mechanisms to prevent the destruction of carbon sinks internationally"*

[33] Pyxis CSB "Comparative Life Cycle Analyses for a variety of Degradable Food Packaging Materials" June 2007

[34] Report 15th January 2008 (HC 76-1 of 2007-08). Para 53 http://www.publications.parliament.uk/pa/cm200708/cmselect/cmenvaud/76/76.pdf

The Committee continued [35] *"A large biofuel industry based on current technology is likely to increase agricultural commodity prices and, by displacing food production, could damage food security in developing countries."*

The use of biofuels in the EU have come under assault once again, this time from the European Commission's own scientific institute, the Joint Research Centre.[36] An unpublished internal report from the research body questions whether the cost of their use is worth the benefits.

The report buttresses worries over biofuels expressed by environment Commissioner Stavros Dimas and research from environmental campaign groups that suggests biofuels may actually contribute to global warming through the deforestation and peat bog burning that is required for biofuel sources such as corn or oil palm trees.

On 3rd April 2009[37] Dr. Peter Brabeck, Chairman of Nestlé said "The water issue comes back to three simple things. The first is infrastructure. If you look worldwide it's about 60% of fresh water that we are losing due to insufficient infrastructure. The second is political decisions. It is absolutely unacceptable that we are using food for biofuels. We need 9,100 litres of water to produce one litre of pure diesel. This is not sustainable."

Friends of the Earth Europe said on 9th July 2008[38] "The political tide in Europe is now turning against biofuels. This vote [in the European Parliament] gives a clear political signal that an expansion of biofuels is unacceptable." Originally viewed by both European leaders and environmentalists alike as an alternative to fossil fuels, biofuels have in the last year become something of an eco-villain, with countless reports showing how production of the fuel source in fact can result in greater greenhouse gas emissions and is a key cause of skyrocketing food prices.

The British Royal Society for the Protection of Birds is also highly critical of using land and water resources for this purpose[39] "Driven by the thoughtless policies of governments around the world, biofuels production is decimating swathes of important habitat and threatening the survival of many species, including Sumatran tigers, orang utans and countless bird species.

Biofuels advocates justify this destruction by citing their potential for combating climate change. However, whilst biofuels can play a part, many of those on the market today don't deliver the greenhouse gas savings they promise and some are even more polluting than the fossil fuels they're meant to replace.[40] There is also evidence that taking land used for growing food, and converting it to growing biofuels, is reducing the amount of food produced and contributing to increasing prices."[41]

On 6th March 2008 the United Kingdom's Chief Scientific Adviser warned that if this continues the world will soon be unable to feed itself.[42]

As the use of renewable resources for polymer production increases, so does the impact on eutrophication due to the application of fertilisers to the land and run-off of nutrients into waterways.[43]

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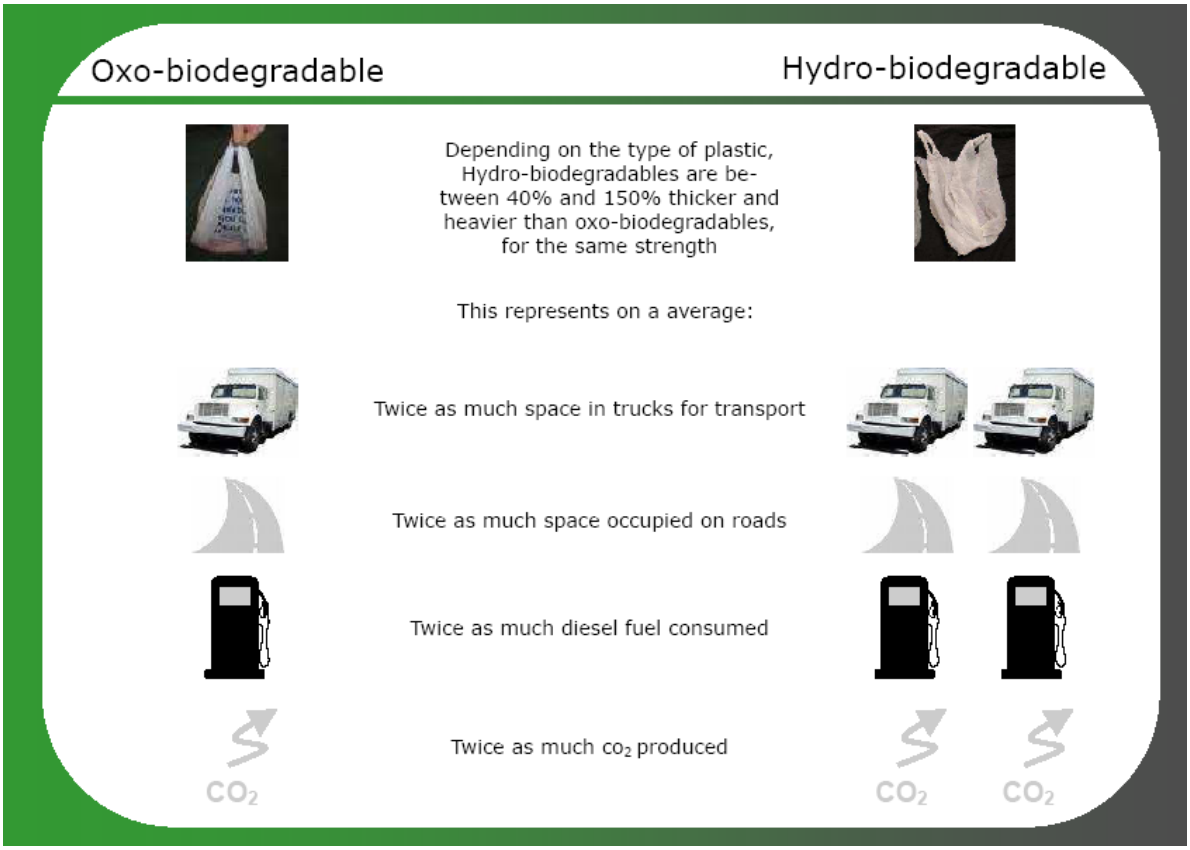
[35] ibid para 63
[36] EU Observer.com 18 Jan 2008
[37] Financial Times http://www.ft.com/cms/s/0/fafa0d4a-1fe5-11de-a1df-00144feabdc0.html?nclick_check=1
[38] http://euobserver.com/19/26463/?rk=1
[39] http://campaigning.rspb.org.uk/eactivist/user/userJ.jsp?CLS@74YQcNH906cWOsj3K3
[40] Compostable plastics can emit methane, which is a greenhouse gas 23 times more powerful than CO_2
[41] See also http://www.slate.com/id/2283299/
[42] The Times 7th March 2008 http://www.timesonline.co.uk/tol/news/environment/article3500954.ece
[43] ExcelPlas (Australia) 2004

Vegetable-based “Compostable” plastics are up to 400% more expensive, and they are sometimes not strong enough for use in high-speed machinery. Usually they are not strong enough for weight-bearing packaging unless mixed with oil-based plastics. Also, it is wrong to use land, water and fertilisers to grow crops for bioplastics and biofuels, which drives up the cost of food for the poorest people. See also The Guardian 26th April 2008[44]

The same applies to growing cotton or jute to make durable bags. These rapidly become unhygienic[45] if a tomato is squashed or milk spilled, and they become a durable form of litter, but they can be made from washable oxo-bio plastic, to last up to 5 years. Why not use an ordinary oxo-biodegradable plastic bag time and time again during its useful life (usually about 18 months) instead of buying an expensive cloth bag? (See further p 25 below).

Hydro-biodegradable plastics can emit methane under anaerobic conditions in landfill, and methane is 23 times more potent for global warming[46] than CO_2.



For the reasons given under “Composting” below, compostability of plastics is really an irrelevance.

The packaging technical manager of Tesco (Britain’s largest supermarket) said on 20th October 2009 that the supermarket “does not see the value in packaging that can only be industrially composted” and that “local authorities do not want to touch it, as it can contaminate existing recycling schemes.” A few days earlier, Tesco’s head of waste and recycling had told a conference that the supermarket group was “not taking compostable packaging any further.”

[44] http://www.guardian.co.uk/environment/2008/apr/26/waste.pollution?gusrc=rss&feed=networkfront
[45] http://www.carrierbagtax.com/downloads/Microbiological_Study_of_Reusable_Grocery_Bags.pdf
[46] IPCC (Inter-Governmental Panel on Climate Change) Report page 47 www.ipcc.ch/pub/wg1TARtechsum.pdf

C. PHOTO-DEGRADABLE PLASTICS

These react to ultra-violet light, but unless they are also oxo-biodegradable they will not degrade in a landfill, a sewer, or other dark environment, or if heavily overprinted.

ENVIRONMENTAL BENEFITS OF OXO-BIODEGRADABLE PLASTICS

There are several areas where oxo-biodegradable plastic can have a major beneficial impact on the environment:

1. RECYCLING OF PLASTICS

Recyclers should be worried about hydro-biodegradable or "compostable" plastics, because they will certainly compromise an oil-based recycling stream. Oxo-biodegradable plastics will not.

The Oxo-biodegradable Plastics Association supports the recycling industry, but recycled plastics are not normally degradable and will, like ordinary plastics, accumulate for decades if they get into in the open environment. However, recycled plastic and ordinary plastic can now be made oxo-biodegradable by the inclusion of a pro-degradant formulation at the extrusion stage.

Oxo-biodegradable plastics are now a fact of life. They provide a significant environmental benefit and they are increasingly popular. In 2008 one company alone sold enough formulation to make more than 5 billion plastic products.

According to the respected laboratory, RAPRA[47], "Oxo-biodegradable packaging is recyclable as would be any similar plastic material without the pro-oxidant additive.

Recycling of clean plastic waste within the factory is commonplace and well understood. However, recycling of contaminated post-consumer plastic waste is often uneconomic, and some national standards (eg Indian Standard 14534 para. 7.3.4) discourage it.

This briefing is intended to assist recyclers and the public to understand the relationship between biodegradability and recyclability of plastics.

1(a) OXO-BIODEGRADABLE PLASTICS

Oxo-biodegradable plastics have been in commercial use since the 1970s, and are based on commodity polyolefins, particularly polyethylene and polypropylene. Their performance during manufacture and use is indistinguishable from that of regular polyolefins, and their biodegradation is caused by formulations that promote transition metal ion oxidation in the presence of oxygen.

The length of the useful life of an oxo-biodegradable plastic product is determined by antioxidants (processing stabilisers and UV stabilisers) contained within the formulation, which can be modified so that the plastic product degrades according to whatever timescale is required.

Obviously if any plastic is going to be recycled it will have to be collected and recycled before it has become embrittled. Oxobiodegradable products such as shopping bags

47 http://www.rapra.net/consultancy/biodegradable-plastic.asp

will normally have a useful life before embrittlement of about 18 months, and if they have not been collected and recycled by then, they probably never will be.

It is possible to tell by a simple xrf test whether a recyclate contains any pro-degradant additive, and if so in what proportion, and this information should be included in the material data sheets provided by recyclers to their customers. Handheld xrf devices are now available.

A. New oxo-biodegradable products made with recyclate

If a new product is to be made with recycled polymer which contains or might contain a pro-degradant formulation and the new product is intended to be degradable, the process is obviously straightforward, as a pro-degradant effect is actually desired. This applies particularly to recycling of oxo-biodegradable offcuts in plastic factories, or where used oxo-biodegradable "back-of-shop" plastics (e.g. shrink-wrap pallet-wrap, bread-wrapping etc) are sent back for recycling into more oxo-biodegradable products.

B. Short-life products

If the new product to be made from recyclate which contains or might contain a pro-degradant formulation, is intended for short-life products such as refuse-sacks, bin-liners, shopping bags, bread wrappers etc. the effect of any pro-degradant formulation is unlikely to manifest itself during the intended service-life, and biodegradability for such items is in any event desirable. It is desirable because a proportion of these items will always find their way into the land or sea environment, where they would otherwise subsist for decades after they had been discarded.

C. Long-life products

Since polymers lose stabilisers every time they are reprocessed, it is good practice to add new stabilisers each time, whether the feedstock contains oxo-biodegradable plastic or not. If suitably formulated, the stabilisers will also neutralise any pro-oxidant which may still be effective.

C(1) Building Films

If the new product to be made is a plastic film intended for long-term durability - such as a building film for damp-proofing or waterproofing, the presence of oxo-biodegradable additive is irrelevant. This is because these films are buried under soil or concrete or sandwiched between bricks, with no access to oxygen. The process of oxo-biodegradation cannot proceed in the absence of oxygen.

Further, the specification in some countries for some of these films requires the use of a virgin polyolefin compound[48] and recyclate is not therefore used. For all other building films the specification will usually require the use of stabilisers.[49] There will of course be no pro-degradant formulation in recyclate chosen from conventional in-house scrap.

C(2) Pipes

(a) ISO Standard 8779 "Plastics piping systems — Polyethylene (PE) pipes for irrigation" provides at para. 4.2 that only clean reprocessable material generated from a manufacturer's own production may be used if it is derived from the same resin as used for the relevant production. As the origin of the material will be known, it will not therefore be used for this purpose if it contains any pro-degradant formulation.

(b) European Standard EN 12201-1 provides at para 4.3 that items such as PE pipes for water for human consumption, cannot be produced from recycled material other than process regrind. Residues of oxo-biodegradable materials are likewise not an

[48] Eg South African Bureau of Standards Specification 952-1985 para. 3.2.2
[49] South African Bureau of Standards Specification 952-1985 para. 3.2.1

issue here. Indian Standard 14534 provides[50] that recycled plastic may not be used at all for products which come into contact with foodstuffs, pharmaceuticals and drinking water.

(c) SABS51 piping is manufactured to a specification which permits the use of recyclate only from "in-house scrap." Small bore piping class 6 and 10 is usually LDPE and, larger sizes, HDPE. "In-house scrap" is scrap which has been generated during manufacture of the SABS grade pipe which can be chipped up and added back.

There is therefore no difficulty with the manufacture of such piping, as the origin of the recyclate is known and it will not therefore be used for this purpose if it contains any pro-degradant formulation.

(d) "SABS Equivalent" piping is manufactured from 100% recycled material according to the SABS specification but is not marked. Usually HDPE with from 5-20% LDPE blended for flexibility. For a quality product where a guarantee is demanded, clean industrial scrap is used where product history (material source and material grade) is known. This will not therefore contain a pro-degradant formulation.

(e) Agricultural and Domestic piping is manufactured in South Africa from 100% LDPE scrap. Normally the same scrap is used as in (c) above, but it should only be used in low-tech situations if the origin of the recyclate is unknown. Stabilisers should always be added if there is any doubt about the origin of the recyclate, and there is a case for an industry specification for this category of piping, which would include a requirement to add stabilisers.

"Low tech situation" refers to small bore piping Class 3 and 6 used for piping water to cattle or game troughs or on domestic irrigation systems, essentially at low pressures.

1(b) HYDRO-BIODEGRADABLE PLASTICS

The second class of biodegradable plastics is the hydro-biodegradables (or "compostables"), which are generally based on intermediates of biological origin derived from crops, and cannot be recycled with normal oil-based plastics.

Crop-based plastics were developed some 20 years after their oxo-biodegradable counterparts, and there are two sub-classes of different origins.

The earliest was poly (3-hydroxy butyrate). PHB is produced biologically from sucrose. This is an expensive product with a relatively low thermal decomposition temperature, which was partially overcome by varying the alkanoate structure (PHA). The second sub-group of hydro-biodegradable polyesters are the synthetic aliphatic polyesters, which are in some cases based on biological intermediates (e.g. polylactic acid - PLA).

Both sub-groups are physically incompatible with main stream packaging wastes (PE, PP, ABS and PET) and aliphatic polyesters cannot be readily reprocessed with commercial polyesters, due to their thermal incompatibility

Plasticised-starch is a different type of bio-based plastic used in packaging. This material has acceptable initial properties but is sensitive to hydrolysis during use, and cannot normally be re-processed for use in the same application. Like other bio-based plastics, they are not compatible with mainstream plastics used in packaging and cannot be co-recycled into useful secondary products.

Hydro-biodegradable plastics, unlike oxo-biodegradable plastics, cannot therefore be recycled with the most abundant components of plastic waste. They therefore have to be segregated from the waste stream and treated separately, with considerable increase in cost. Furthermore it is difficult for the manufacturers of recyclate to physically distinguish between hydro-biodegradable and normal plastic.

[50] 8.5
[51] South African Bureau of Standards

Hydro-biodegradable plastics (often referred to as bioplastics) have been called into question by recyclers[52] and Recoup's project manager has warned that starch-based plastics could "have a negative impact on plastics recycling as a whole.53 …. the fear is that bioplastics will increasingly find their way into the plastics recycling stream – impacting on quality and un-doing the work done on raising public awareness of plastics recycling."

Recyclers should therefore be concerned to see that hydro-biodegradable plastics are not encouraged.

2. LITTER

Policymakers need always to consider what happens to waste plastic products which escape collection and end up as litter.[54]

According to The Independent Newspaper[55] a "plastic soup" of waste floating in the Pacific Ocean is growing at an alarming rate and now covers an area the size of the continental United States. If all short-life plastics had been oxo-biodegradable this environmental menace would not exist.

Discarded conventional plastics remain in the environment for many decades, and are often impossible or too expensive to collect, so recycling, landfill, composting, and incineration are not options for dealing with them. If collected, oxo-biodegradable plastics can be recycled or incinerated, and if not collected they will degrade and disappear, leaving no harmful residues.

Exposure to sunlight accelerates degradation, but the process of oxo-bio-degradation, once initiated, continues even in the absence of light, so long as air is present. The plastic will degrade much more quickly in the open than in a building, and in warm weather will disappear more quickly. Of course, if the product has been exposed to air for some time before being discarded it will disappear in an even shorter time thereafter.

Hydro-biodegradable plastics do not rapidly fragment and degrade in an abiotic outdoor environment but they do biodegrade in a highly biotic environment (such as a composting plant), in contact with soil micro-organisms.

More careless disposal?

It is sometimes said that that people dispose more carelessly of biodegradable plastics, and this is an argument which would if true apply to hydro-biodegradable as well as oxo-biodegradable, plastics.

It is not however true. Bio-degradable plastic bags have now been dispensed by supermarkets for more than five years, but there is no evidence that people dispose more carelessly of them, and they have not been encouraged to do so. Pick up any piece of plastic litter and you are most unlikely to find the word "biodegradable" on it. It is unreal to think that litter-louts will read the label to see whether it is degradable before deciding to throw it away.

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[52] Materials Recycling Weekly 20 Nov 2006

[53] Addressing the Local Authority Recycling Advisory Committee conference in November 2006. RECOUP (www.recoup.org) is the UK's national NGO developing plastics-recycling, promoting best practices and providing educational and training tools.

[54] See statement by Member of European Parliament, footnote 6

[55] **05/02/2008**
http://www.independent.co.uk:80/environment/the-worlds-rubbish-dump-a-garbage-tip-that-stretches-from-hawaii-to-japan-778016.html

But suppose for the sake of argument that 10% more were discarded. If 1,000 conventional and 1,100 oxo-biodegradable bags were left uncollected in the environment, 1,000 conventional bags would remain in the rivers, streets and fields for decades, but none of the oxo-biodegradable bags would be left at the end of the short life programmed into them at manufacture.

Education may have some effect, but there will always be people who will deliberately or accidentally discard their plastic waste. What will happen to all the plastic waste that will not be recycled or will not be incinerated, and instead will litter the countryside - would it not be better if the discarded plastic were all oxo-biodegradable?

To limit or discourage the availability of all types of plastic bags is not the answer, as there are so many purposes for which they are ideal. For the following reasons paper bags and re-usable bags should not be encouraged.

ALTERNATIVES

Compare different materials, according to criteria like weight, energy and volume of reduction. If we take 100% as a starting point - without plastic we would have about 484% in terms of **weight**. In terms of **energy consumption**, with plastics if we take 100%, without plastic we will have around 300%. The same in volume of waste - with plastic and without plastic we have almost 300%. [56] The Denkstatt study in Austria[57] has found that plastic saves 2.300 million GJ in energy per year. This equates to 50 million tonnes of crude oil – that is 194 very large oil tankers products. They equally prevent GHG emissions of 120 million tonnes per year.

Paper Bags

The process of making paper bags causes 70% more atmospheric pollution than plastic bags. Paper bags use 300% more energy to produce, and the process uses huge amounts of water and creates very unpleasant organic waste. When they degrade they emit methane and carbon dioxide. Paper bag production use and disposal results in 3.3 times the greenhouse gas emissions associated with HDPE plastic bags. The global-warming impact of paper bag use is almost twice that of conventional plastic bags.[58]

Water use for paper and compostable-plastic bags is more than 16 times the use for HDPE plastic bags.[59] Solid waste production is 2.7 times greater by weight for paper bags than for HDPE plastic bags.[60]

A stack of 1000 new plastic carrier bags would be around 2 inches high, but a stack of 1000 new paper grocery bags could be around 2 feet high. It would take at least seven times the number of trucks to deliver the same number of bags, creating seven times more transport pollution and road congestion.

Also, because paper bags are not as strong as plastic, people may use two or three bags inside each other. Paper bags cannot normally be re-used, and will disintegrate if wet.

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[56] Prof. Emo Chiellini, Professor of Fundamentals of Technologies, University of Pisa. Simpósio Internacional de Plásticos Degradáveis e Biodegradáveis 6th June 2007. See also Polymers and the Environment, 1999, Chapter 4, Management of Polymer Wastes, p. 78-81 and Degradable Polymers 2nd edition, Chapter 1).
[57] June 2010
[58] California Master Environmental Assessment March 2010 page 31
[59] Ibid. page 35
[60] Ecobilan (2004)

Re-usable Bags

Long-term re-usable shopping bags are not the answer. They are much thicker and more expensive, and a large number of them would be required for the weekly shopping of an average family. 30,000 jute or cotton bags can be packed into a 20-foot container, but the same container will accommodate 2.5 million plastic carrier-bags. Therefore, to transport the same number of jute or cotton bags 80x more ships and trucks would be required than for plastic bags, using 80x more fuel and emitting 80x more CO_2.

Because of high emissions associated with cotton production and the fact that waste bags would need to be used in addition to the cotton bags, the cotton bag would have to be used more than 180 times before its climate impact is smaller than recycled plastic bags.[61] Further, it is not practical to recycle cotton or jute bags.

In fact UK Government (DEFRA) research shows that 80 per cent of people re-use their plastic carrier bags in the home.[62]

Long-term reusable bags are not hygienic if a tomato is squashed or milk is spilled. Research by Guelph Chemical Laboratories in Canada in 2008[63] has shown that "re-usable grocery bags can become an active microbial habitat and a breeding-ground for bacteria, yeast, mold, and coliforms. …. The unacceptable presence of coliforms - ie intestinal bacteria, in some of the bags tested, suggests that forms of E.Coli associated with severe disease could be present in a small but significant proportion of the bags." Similar research has been carried out with similar conclusions at the University of Arizona[64] who found that consumers almost never wash re-usable bags.

The Environment and Plastics Industry Council of Canada commissioned a study on re-usable bags in 2009 which found that 64% of the bags showed bacterial contamination. Almost 30% had bacterial counts higher than those considered safe for drinking water. They noted that although in theory these bags can be cleaned, it is difficult to thoroughly dry them without encouraging microbial growth.

Shoppers do not always go to the shop from home, where the re-usable bags would normally be kept, and consumers are unlikely to have a re-usable bag with them when buying on impulse items such as clothing, groceries, CDs, magazines, stationery etc. Research conducted for the Scottish Government[65] showed that 92 per cent of people think re-using carrier bags is good for the environment but 59 per cent forget their re-usable bags and have to take new ones at the checkout.

Why not just re-use an oxobidegradable carrier bag many times over? It is much smaller and lighter and can be carried in a pocket or handbag.

As durable bags are a cost to the consumer and carrier-bags are a cost to the supermarket, one can easily undestand why supermarkets are in favour of reducing

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[61] Ibid. pages 31/32

[62] http://www.brc.org.uk/details04.asp?id=1109&kCat=&kData=263&sCat=Retail+Myths

[63] (http://www.carrierbagtax.com/downloads/Microbiological_Study_of_Reusable_Grocery_Bags.pdf)

[64] http://www.necn.com/06/25/10/Study-Eco-friendly-bags-carry-bugs-bacte/landing_health.html?blockID=260864&feedID=4210 http://www.mirror.co.uk/news/top-stories/2010/07/01/killer-bugs-in-your-re-used-shopping-bags-115875-22373748/ http://www.dailymail.co.uk/health/article-1290983/Beware-deadly-toxins-eco-friendly-shopping-bag.html

[65] (http://www.scotland.gov.uk/Topics/Environment/funding-and-grants/carrier-bag-case-studies/Q/EditMode/on)

the number of carrier bags and increasing the number of durable bags! Even those who give the profit to charity have still passed the cost to their customers.

For those who believe in long-term re-usable bags, they can be made from washable extended-life oxo-biodegradable plastic and will last for 3-5 years.

Risk of Persistency and Bio-accumulation?

Fragmentation occurs as an intermediate stage during degradation of both oxo-biodegradable and hydro-biodegradable plastics.

It is not of course acceptable to apply conventional plastics to the soil even if they are fragmented, since physical shredding alone does not transform plastic into a biodegradable product. However, the properties of oxo-biodegradable plastic are quite different from those of the original plastic. The transformed plastic behaves in the same way as nature's wastes. It is bio-assimilated by the same bacteria and fungi, and they convert the degraded plastic to cell biomass, just like lignocellulosic materials such as straw, leaves and twigs.

Eco-toxicity tests[66] have demonstrated that oxo-biodegradable formulations produce no immediate, or cumulative, adverse effects on the soil, and the traces remaining after degradation are in such minor parts per million (in some cases, per billion) that no harmful effects will occur. Some of these materials can also be found in hydro-biodegradable ("compostable") products.

Oxo-biodegradable plastics do not contain "heavy metals."[67]" Metal compounds used in oxo-biodegradable polymers and listed in European Directive 67/548/EC are not banned. The Directive simply controls their marketing and use, and they are marketed and used accordingly.

The metals used are in any event in the form of salts. For example Sodium is a very dangerous metal, but sodium chloride is in everyday use as table salt. Sodium is not used in Oxobiodegradable plastic.

The UK Food Standards Agency's Expert Group on Vitamins and Minerals[68] has carried out a risk assessment which shows that the metal salts used in commercial oxo-biodegradable plastics are trace-elements necessary for healthy plant and human growth.

Like lignocellulose (and unlike the hydro-biodegradable plastics which discharge their CO_2 to atmosphere during composting), oxo-biodegradable plastics are sequestered by the soil and enhance the "land carbon sink"

3. LANDFILL

Plastic waste should not be sent to landfill if at all practicable. After collection it should be recycled[69], or incinerated for energy-recovery[70]. However, as mentioned above, the recycling option for a normal plastic waste stream is not practicable for hydro-biodegradable compostable plastics, which have to be treated separately and

[66] See G. Scott and D.M. Wiles, *Degradable Polymers: Principles and Applications*, Kluwer, 2002, Chapter 13, Section 9.11, page 472, et seq

[67] The EU Packaging and Packaging Waste Directive 94/62/EC Article 11 designates "heavy metals" as lead, cadmium, mercury and hexavalent chromium. These are not transition metals and are therefore not used as peroxidation catalysts in oxo-biodegradable plastics.

[68] UK Food Standards Agency (May 2003) *Expert Group on vitamins and minerals" Part 3 Trace Elements, Risk Assessment.*

[69] See OPA Position Paper on Recycling above, also at http://www.biodeg.org/recycling.htm

[70] Plastic has a higher calorific value than any other element of waste. The energy released in clean-burn municipal incineration by a single carrier bag keeps a 60 watt light bulb burning for one hour. (APME/Plastics Europe 2006).

at high cost. Also, hydro-biodegradable plastics have a lower calorific value when incinerated.

Some plastic waste will nevertheless be collected and sent to landfill.

What exactly is the environmental problem with plastic being buried in landfill? Animals can't find and eat it, it doesn't leach chemicals into the water-table, and plastic bags occupy a tiny proportion of the space in landfill.

"0.2% of the average household dustbin is plastic carrier bags … hence a tax on plastic carrier bags alone would be unlikely to have any significant impact on volumes of waste".[71]

The fraction of landfill represented by plastic shopping bags is 0.05%. This is based on domestic waste being 17% of landfill and plastic bags being 0.2% of the average dustbin.[72]

In California plastic bags account for only 0.3% of the total waste stream and plastic grocery bags only 0.13%[73]

A far greater impact on landfill space would be made by diverting away from landfill bricks, concrete, wood, glass and other building materials and other items such as household appliances, which occupy much more space.

The main benefit of oxo-biodegradability is not for plastic waste which is sent to landfill, but for plastic waste which gets out into the environment, where it will otherwise accumulate for many decades on land and in the oceans.

The aims of the EU Landfill Directive 1999/31/EC (as amended[74]) are stated in the following recitals at the beginning of the document:

(3) the prevention, recycling and recovery of waste should be encouraged as should the use of recovered materials and energy so as to safeguard natural resources and obviate wasteful use of land.

Oxo-biodegradable plastics, like their traditional counterparts, can be re-used during their useful life and/or recycled and incinerated with high energy-recovery.

The most valuable asset for a landfill-operator is space. Plastic bags are extremely compact, and plastic grocery bags and all plastic retail bags together take up less than 1% of space in landfills - a tiny amount. However, conventional plastic bags take up more space than necessary because they trap air, they do not disintegrate rapidly, and thus inhibit the decomposition of their contents in the landfill.

Oxo-biodegradable plastics approved by this Association will disintegrate in a landfill so long as oxygen is present. Oxygen levels will vary according to factors such as how loose or compressed the waste was when it was buried, how much u/v light is available, and how much further waste material or earth is added to the landfill over what period of time. A fragmented oxo-biodegradable bag will settle more easily than an ordinary plastic bag with trapped contents, and will occupy less space. Test reports for individual products will measure the ability of the material to degrade within a reasonable period.

(4) further consideration should be given to the issues of incineration of municipal and non-hazardous waste, composting, biomethanisation, and the processing of dredging sludges;

[71] Plastic Bag Tax Assessment, HM Treasury, December 2002
72 Packaging and Films Association 2007
[73] Master Environmental Assessment March 2010 page 14/15
[74] 1882 of 2003

Oxo-biodegradable plastics can be incinerated with high energy recovery.

(12) protective measures [should] be taken against any threat to the environment in the short as well as in the long-term perspective, and more especially against the pollution of groundwater by leachate infiltration into the soil.

Oxo-biodegradable plastics do not cause harmful leachate infiltration, and commercial oxo-biodegradable formulations approved by the OPA have been certified non eco-toxic.

(16) measures should be taken to reduce the production of methane gas from landfills, inter alia, in order to reduce global warming, through the reduction of the landfill of biodegradable waste and the requirements to introduce landfill gas control;

Hydro-biodegradable ("compostable") plastics will biodegrade and emit CO_2 at a high rate in the surface layers of a landfill if there is enough microbial activity, and in the depths of a landfill, in the absence of air, they generate methane, which is a powerful greenhouse gas. Methane is also highly combustible and is a cause of explosions.

Decomposition deep in a landfill is not therefore desirable. Whilst oxo-biodegradable plastics fragment and biodegrade in the upper layers of the landfill (see above) and emit CO_2 at a low rate there in the presence of oxygen, abiotic degradation cannot proceed in the absence of oxygen. This is a benefit, because the carbon is trapped and not emitted to atmosphere.

Article 2 (m) of the Landfill Directive defines "biodegradable waste" as *"any waste that is capable of undergoing anaerobic or aerobic decomposition, such as food and garden waste and paper and cardboard."* However, the reason stated in recital 16 above for reducing the landfill of biodegradable waste does not apply to oxo-biodegradable plastics because, as indicated above, abiotic degradation cannot proceed in the absence of oxygen - unlike food and garden waste, paper, cardboard, and hydro-biodegradable plastics.

It is an important factor that an oxo-biodegradable plastic bag is much lighter than a paper, cotton, or jute bag, and is even lighter than a hydro-biodegradable bag.[75] As municipalities and waste-management companies have to pay to put trash in landfills, and as charges are based on weight, it costs much more to put paper, cotton, jute or hydro-biodegradable plastic bags in a landfill than ordinary or oxo-biodegradable plastic bags.

The Report on "The impacts of degradable plastic bags in Australia" prepared by ExcelPlas/ Nolan-ITU on 11 September 2003 for the Australian Government noted at 7.3 that: "[hydro] degradable polymers with starch content have higher impacts upon greenhouse due to methane emissions during landfill degradation and N_2O emissions from fertilizing crops." Methane is 23 times more potent for global warming[76] than CO_2.

4. AGRICULTURE AND HORTICULTURE

Oxo-biodegradable plastic has useful applications in agriculture and horticulture.[77] For many years farmers and growers have used plastic sheets to protect their crops and to inhibit weeds, but after the crop has been harvested many thousands of square kilometres of dirty plastic have to be removed and disposed of. This is a very expensive process, and creates huge quantities of contaminated waste, which cannot be burned, or recycled into useful products.

[75] depending on the type of plastic, hydro-biodegradables are between 40% and 150% thicker and heavier than oxo-biodegradables for the same strength.
[76] IPCC (Inter-Governmental Panel on Climate Change) Report page 47
www.ipcc.ch/pub/wg1TARtechsum.pdf
77 see also COMPOSTING (section 7 below).

Oxo-biodegradable plastic sheets are being developed to be programmed at manufacture to degrade after the harvest[78]. The degraded material can then be ploughed into the soil where it completes the biodegradation process and becomes a source of carbon for next year's plants**.** Alternatively it can be placed in a corner of the farm under a net, where it will degrade and disappear leaving no harmful residues.

Oxo-biodegradable plastics have been used as protective films in agriculture in many countries (including USA, China, Japan and the EU). They are applied to the land in the same way as straw to retain moisture and to increase root temperatures.

On 20th May 2003 the Development and Cooperation Committee of the European Parliament passed a resolution calling on the European Commission not to fund environmentally harmful projects in the ACP (Africa, Caribbean and Pacific) countries. The Committee specifically called on the Commission to encourage the use of biodegradable materials in the banana-growing process in ACP countries who benefit from the EU's Special Framework of Assistance for suppliers of bananas. Oxo-biodegradable plastic films are being used as banana bags in commercial operations.

5. ENERGY RECOVERY

In some countries, including Germany, incineration is popular, and the necessary equipment is in place. Oxo-biodegradable plastic can be incinerated with energy recovery in the same way as conventional plastic, and has a higher calorific value than the hydro-biodegradable alternative, or than damp paper, cotton or jute.

6. WASTE COLLECTION

There has to be a collection method for organic waste. Transparent oxo-biodegradable sacks are currently in common use for this purpose and are much better than wheeled bins or conventional plastic sacks. Oxo-biodegradable sacks are much better than bins because:

They are quicker and easier to collect than bins, which require the collectors to walk the distance from vehicle to house four times.
They can be produced in a wide variety of sizes to suit particular requirements
They do not need expensive vehicles with bin-lifting equipment
They are easy for householders to store, and can be supplied in rolls
They can be sealed when filled, so eliminating smells and flies which usually attend conventional waste bins
Transparent sacks enable collectors to see the contents
They are not as visually-intrusive as bins
Bins need to be washed
Bins are bulky items, which are expensive to purchase, store, and transport
The bins themselves, usually made from heavy non-degradable plastic, eventually have to be disposed of.

7. COMPOSTING

Composting is not the same as biodegradation in the environment. Composting is an artificial process operated according to a much shorter timescale than the processes of nature. Therefore, Standards such as ISO 17088, EN13432, and their American (ASTM D6400-04; D6868) and Australian (AS 4736-2006) equivalents, designed for compostable plastic should not be used for plastic which is designed to biodegrade if it gets into the environment.

78 It is not so far been found possible to determine the exact month in which degradation will take place. This is because there are so many variables from climate to climate, and even from farm to farm.

Composting of organic waste makes sense, but compostable plastic for shopping bags, food packaging, shrink-wrap etc does not. It is up to 400% more expensive than ordinary plastic; it is thicker and heavier and requires more trucks to transport it; recycling with oil-based plastics is impossible; it uses scarce land and water resources to produce the raw material, and substantial amounts of hydro-carbons are burned and CO_2 emitted, by the tractors and other machines employed. If buried in landfill, compostable plastic will emit methane (a greenhouse gas 23 times more powerful than CO_2) in anaerobic conditions.

Many industrial composters of organic waste around the world do not want plastic of any kind in their feedstock, because it is difficult to separate biodegradable plastic from ordinary plastic.

Home composting of plastic packaging can be dangerous and should not be encouraged, as it is often contaminated with meat, fish, or poultry residues, which will attract rats and other vermin. Also, temperatures may not rise high enough to kill the pathogens.

European standard EN 13432 and ASTM D6400[79] are specifications for *compostable* plastic packaging, and EN13432 states specifically at para. 1 that it does not take into account packaging waste which may end up in the environment through uncontrolled means, ie as litter.

EN 13432, ASTM D6400 and the other standards for compostability are not appropriate for testing oxo-biodegradable plastics. This is because they are based on measuring the emission of carbon dioxide during degradation over a short timescale. Hydro-biodegradable plastic is compliant precisely because it emits CO_2 (a greenhouse gas) at a high rate. Oxo-biodegradable plastics do not mineralise rapidly in the artificial biometric test in EN 13432 and ASTM D6400 but they do biodegrade in soil after application of the compost to the soil.

It is worth noting that EN 13432, does not require that plastics biodegrade during and after composting within any particular time-scale. The Note to paragraph 5 of EN 13432 says: "It is important to recognise that it is not necessary that biodegradation of packaging material or packaging be fully completed by the end of biological treatment in technical plants but that it can subsequently be completed during the use of the compost produced." This is what oxo-biodegradable plastic does, and it is consistent with the behaviour of nature's waste products such as twigs, leaves and straw, which take years to biodegrade fully. Oxo-biodegradable plastics will biodegrade much more quickly than these natural materials.

If a leaf were subjected to the CO_2 emission tests included in EN13432 it would not pass! Leaves are not of course required to pass any such test, but it shows how artificial the test is.

Another problem with EN 13432, mentioned above, is that it requires almost complete conversion of the carbon in the plastic to CO_2, within 180 days, thus depriving the resulting compost of carbon, which is needed for plant growth, and wasting it by emission to atmosphere - contributing to climate-change.

Conversion of organic materials to CO_2 at a rapid rate during the composting process is not “recovery” as required[80] by the European Directive on Packaging and Packaging Waste (94/62/EC as amended),[81] and should not really be part of a standard for composting. Nature’s lignocellulosic wastes do not behave in this way,

[79] There are also other national and international equivalents.
[80] Annex II para. 3
[81] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1994L0062:20050405:EN:PDF

and if they did they would have little value as soil improvers and fertilisers, having lost most of their carbon.

The EU Directive does NOT require that when a packaging product is marketed as "degradable" or "compostable" conformity with the Directive must be assessed by reference to EN13432. Although the Directive[82] provides that conformity with its essential requirements may be presumed if EN 13432 is complied with, it does not exclude proof of conformity by other evidence. Indeed Annex Z of EN13432 itself says that it provides only *one means of conforming* with the essential requirements.

EN 13432 does not apply at all to applications other than *composting* of *packaging.*

Thick cross-section products, over 150 microns, will usually fail to meet the composting standards.

Oxo-biodegradable plastic does not degrade quickly in low temperature "windrow" composting, but development is ongoing for "in-vessel" composting of oxo-biodegradable plastic at the higher temperatures required by the EU animal by-products regulations.

8. WASTE MINIMISATION

As oxo-biodegradable bags are thinner than hydro-biodegradable or paper bags of the same strength, they produce a much smaller tonnage of plastic waste. Also, as they will totally degrade, they cease to exist at the end of their programmed life. As noted above, a stack of 1000 new plastic carrier bags would be around 2 inches high, but a stack of 1000 new paper grocery bags could be around 2 feet high.

9. COUNTERFEITING

Many high-value cosmetics and other products are sold in plastic bottles, jars, and other plastic containers. Often these empty containers are collected and refilled with an inferior product and sold as the genuine article.

Manufacturers of high-value products are now demanding oxo-biodegradable containers which will degrade soon after use and will therefore make counterfeiting more difficult.

A hand-held device called the "d2Detector" is available from one of the Association's member-companies, Symphony Environmental, which will determine in 60 seconds whether the packaging is genuine.

10. OXO-BIODEGRADABLES v HYDRO-BIODEGRADABLES

To summarise, **oxo**-biodegradable plastics have the following advantages:

- They will degrade in any outdoor or indoor environment where oxygen is present, even in the absence of moisture. This is a very important factor in relation to litter, because a large amount of plastic waste cannot be collected. By contrast compostable plastics need a highly microbial environment such as a composting plant.

- Oxo-biodegradable plastic can be programmed at manufacture to degrade within a timescale to suit the user's requirements. The rate of degradation of hydro-biodegradable plastics cannot be controlled.

- Oxo-biodegradable plastics are stronger and more versatile.

[82] Article 9(2)

- They are much cheaper
- They are thinner, and use less space to store and transport, and less material to produce
- They can be used for high-clarity applications.
- They can be recycled and can be made from recyclate.
- Less energy is required to produce and transport them.
- No genetically-modified ingredients
- Ideal for frozen food
- Can be used in high-speed machinery (such as for bread packaging) but the performance of hydro-biodegradable plastics in these machines is often not acceptable.
- Can be incinerated with much higher energy-recovery than hydro-biodegradable plastic
- They can be made with the same workforce and machinery as conventional plastic products, but hydro-biodegradable products are made by a quite different process.

It seems wrong to divert agricultural resources away from food production when there is so much hunger in the world, and to use fertilisers and pesticides unnecessarily

OXO-BIODEGRADABLE PRODUCTS AVAILABLE

Carrier bags or “shopper-bags” which consumers use to take away their purchases from the shop
Refuse sacks, which consumers buy in rolls at the shop, and use for disposal of their ordinary household waste.
Aprons, for the protection of garments, in the home, hospitals, restaurants, workshops etc.
Bags to contain dog faeces collected in parks, gardens, etc
Bin liners
Gloves
Plastic sheeting for a variety of applications in agriculture and horticulture.
Plastic film for wrapping newspapers and magazines.
Bread bags
Frozen food bags
Wrappers for cigarette packets
Shrink-wrap and pallet-wrap
“Bubble-wrap”
Rigid products such as bottles and cups

Products such as these are now being made and used by some of the world’s largest companies, who undertake many months or even years of due-diligence before they adopt oxo-biodegradability.

More products will become available in due course.

STANDARDS

A standard for oxo-biodegradation[83] has been approved by the British Standards Institution.

The United Arab Emirates[84] and Yemen[85] have published standards for oxo-biodegradable plastic.

The French Standards organisation, AFNOR, published in July 2007 a Standard for oxo-biodegradable plastics in agriculture.[86]

EN13432, ASTM D6400 and their ISO and Australian equivalents have been discussed under "Composting" above. They are designed for compostable plastic and are NOT appropriate for plastic which is designed to self-destruct if it gets into the open environment.

The requirement in EN13432 and similar standards for 90% conversion to CO_2 gas within 180 days is not useful even for composting, because it contributes to climate change instead of contributing to the improvement of the soil. "Compostable" plastic, 90% of which has been converted to CO_2 gas, is therefore virtually useless in compost. Nature's lignocellulosic wastes do not behave in this way.

Oxo-biodegradable plastic products are normally tested according to ASTM D6954-04 "Standard Guide for Exposing and Testing Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation." There are two types of Standards – Standard Guides and Standard Specifications ASTM 6954 is an acknowledged and respected Standard Guide for performing laboratory tests on oxo-biodegradable plastic. It has been developed and published by ASTM International – the American standards organisation. The second Tier of ASTM D6954-04 is directed specifically to proving biodegradation.

Para 4.1 provides that "The guide may be used to compare and relatively rank, the rate and degree of thermal oxidative degradation of a plastic material to a molecular weight range that can be established as biodegradable in a chosen environment. Subsequently, the biodegradation of these degraded polymers in diverse environments such as soil, compost, landfill, and water may be compared and ranked using standard biometric test methods and measuring carbon dioxide evolution."

The tests performed according to ASTM D6954-04 tell industry and consumers what they need to know – namely whether the plastic is (a) degradable (b) biodegradable and (c) non eco-toxic. It is not necessary to refer to a Standard Specification unless it is desired to use the material for a particular purpose such as composting. Note 3 to ASTM D6954-04 provides that if composting is the designated disposal route, ASTM D6400 should be used.

ASTM D6954-04 not only provides detailed test methods but it also provides pass/fail criteria. For example, para. 6.6.1 requires that 60 % of the organic carbon must be converted to carbon dioxide. Therefore if the material does not achieve 60% mineralisation the test cannot be completed and the material cannot be certified. Having achieved 60% mineralisation, the Note to para. 6.6.1 provides that testing may be continued to better determine the length of time the materials will take to biodegrade. It is not however necessary to continue the test until 100% has

[83] BS 8472
[84] 5009:2009
[85] 2391/2010
86 XP_T_54-980__F

been achieved, because it is possible, by applying the Arrhenius relationship to the test results, to predict the time at which complete biodegradation is likely to occur.

Tests on oxo-biodegradable plastic products are usually conducted according to the test methods prescribed by ASTM D6954-04 or BS8472 by independent laboratories such as Smithers-RAPRA (US/UK), Pyxis (UK), Applus (Spain) etc.

Conditions in the laboratory are designed to simulate so far as possible conditions in the real world, but have to be accelerated in order that tests may be done in a reasonable time. Pre-treatment does not invalidate the results as extrapolated to real-world conditions.

It is in fact difficult to keep microorganisms working for years in closed respirometric cells. It is known that many soil microorganisms are unable to be cultured in a laboratory and so it is already an artificial approximation to take microorganisms from the environment and observe them in the laboratory. They live in consortia with many other organisms, especially fungi and bacteria, under natural aeration and rainwater flow, changing mass and energy.

There is no requirement in ASTM D6954-04 for the plastic to be converted to $C0_2$ in 180 days or less because, while timescale is critical in an industrial composting process, it is not critical for biodegradation in the environment. Timescale in the natural environment depends on the amount of heat, light, and stress to which the material is subjected. Nature's wastes such as leaves twigs and straw may take ten years or more to biodegrade, but oxo-bio plastics will biodegrade more quickly than that, and much more quickly than ordinary plastic.

Recent work by Professor Jakubowicz in Sweden has discovered that oxo-biodegradable plastics will biodegrade more readily in soil at ambient temperatures than in compost at elevated temperatures.

In oxo-biodegradable plastics there are anti-oxidants mixed with the resins, and they must be consumed before degradation starts. People sometimes do not understand this sequence and conclude that the additives do not work. An induction period must therefore elapse before degradation starts, due to the presence of the anti-oxidants.

Packaging made from oxo-biodegradable plastic complies with paras. 1, 2 3(a), (b) and (d) of Annex II of the European Parliament and Council Directive 94/62/EC (as amended) on Packaging and Packaging Waste. This Annex specifies the essential requirements for the composition and the reusable and recoverable, including recyclable, nature of packaging.

Oxo-biodegradable plastic satisfies para. 3(a) because it can be recycled. It satisfies para. 3(b) because it can be incinerated. It satisfies para. 3(d) because it is capable of undergoing physical, chemical, thermal or biological decomposition such that most of the finished compost ultimately decomposes into carbon dioxide, biomass and water. It can even satisfy para. 3(c) if composted in an "in-vessel" process.

LEGISLATION

On 18th February 2002 the then EU Environment Commissioner, Margot Wallstrőm, said, in a letter to the Irish MEP Avril Doyle that "it would be consistent with the spirit of Community environment policy and legislation if a state applying a plastic bag tax were to decide to adopt a more beneficial tax rate in relation to biodegradable carrier bags."

On 18th July 2008 Dr. Caroline Jackson MEP (immediate past-Chairman of the Environment, Public Health, and Food Safety Committee of the European

Parliament, and the Rapporteur for the EU Waste Framework Directive) issued a press statement as follows:

"European legislation on waste has tended to concentrate on waste which can be collected, and to encourage people to reduce, re-use, and dispose responsibly of their waste, by recycling, incineration with energy-recovery, or by other disposal routes."

"However, we also need to take account of the fact that we will never succeed in collecting all the waste and that some may remain to disfigure the landscape. This is particularly the case with plastic waste, from errant supermarket bags to agricultural plastic. Where this goes uncollected it can accumulate in the environment, polluting the land and the oceans for many decades, and perhaps for hundreds of years."

"However, technologies have now become available which can produce plastic products such as shopping bags, garbage sacks, packaging etc. which are fit for purpose, but will harmlessly degrade at the end of their useful life. These fall into two broad categories, namely:

1. Hydro-biodegradable plastics, made wholly or partly from crops, which biodegrade in a highly microbial environment, such as composting, and
2. Oxo-biodegradable plastics, made from a by-product of oil-refining, which degrade in the environment by a process of oxidation initiated by an additive, and then biodegrade after their molecular weight has reduced to the point where naturally-occurring micro-organisms can access the material."

"We need to encourage both of these technologies, and to ensure that European Standards are developed which are appropriate to both. It is worth bearing in mind that the Parliament is concerned by the use of scarce land and water resources around the world to produce biofuels in competition with food-crops and the same concern applies to growing crops to make biodegradable plastics, so I hope the European Commission will give more positive support to oxo-bio plastics."

A. TYPE OF LEGISLATION

A government wishing to encourage or require the use of degradable plastic may.

1. impose a tax on conventional plastic, with a lower tax or no tax at all on degradable plastic, or
2. ban the use of conventional plastic, but permit degradable plastic.

B. WHICH PRODUCTS?

Government may apply the legislation

1. to shopping bags alone, or
2. to one or more items on the following list:

    a) Carrier bags or “shopper-bags” which consumers use to take away their purchases from a retail outlet.
    b) Refuse sacks for disposal of household, garden or commercial waste.
    c) Bags to contain dog faeces
    d) Bin liners
    e) Laundry bags

f) Sheets and bags for use in agriculture or horticulture,

g) Film for wrapping newspapers, magazines, and other similar items for delivery.

h) Bread bags and other food packaging film, including frozen food packaging

i) Film for packaging furniture and electrical goods

j) “Bubble-wrap”, shrink-wrap, and pallet-wrap

k) Bottles and other containers for food and beverages

Legislation may authorise the Minister to add more items from time to time, and may specify different commencement dates for different products.

C. TYPE OF DEGRADABLE PLASTIC

Legislation may define “Degradable Plastic” as (1) oxo-biodegradable or (2) hydro-biodegradable, or (3) both.

1. OXO-BIODEGRADABLE plastic means plastic containing a controlled percentage of a pro-degradant additive, which will cause the plastic to degrade by a process of oxo-biodegradation without causing eco-toxicity. Oxo-biodegradation means “degradation resulting from oxidative and cell-mediated phenomena, either simultaneously or successively. Plastic can be proved to be oxo-biodegradable using the test methods prescribed by American Standard D6954-04

2. HYDRO-BIODEGRADABLE plastic means plastic made wholly from materials of vegetable origin which degrade by a process of hydrolysis followed by degradation due to cell-mediated phenomena. Plastic can be proved to be hydro-biodegradable using the test methods prescribed by ISO 17088, American Standard D 6400-04 or D6868; European Standard 13432 or Australian Standard 4736-06.

3. OXO-BIODEGRADABLE and HYDRO-BIODEGRADABLE

D. APPLYING TO WHOM?

Legislation may apply to:

1. Everybody, or
2. Specific sections of the public eg. Restaurants, Supermarkets etc.

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Legislation in:

The Brazilian States of Espirito Santo, Goiás, Piauí and Maranhão, and the cities of Guarulhos, Osasco, Jundiaí, Sorocaba, Piracicaba, Salvador, and João Pessoa have adopted options A2, B2, C3 and D2

Neuquen Province, Argentina has adopted options A2 , B2, C3 and D2

The UAE has adopted A2, B2, C1, D1

Yemen has adopted A2, B2, C1, D1

Morocco has adopted A2, B1, C1, D1

Mexico City has adopted A2, B2, C3, D2

Slovenia has adopted options A1, B2, C3, D2

Montenegro has adopted A1, B2, C3, D1

Barbados has adopted A1, B2, C3, D1

Mauritius has adopted A2, B1, C1, D1

Togo has adopted A2, B1, C1, D1

Gabon has adopted A2, B1, C1, D1

Congo-Brazzaville has adopted A2, B1, C1, D1

Rwanda has adopted A2, B1, C1, D1

Some legislators in the United States have been led down the wrong path by the cornstarch lobby into preferring hydro-biodegradable to the exclusion of oxo-biodegradable plastic. (see http://www.biodeg.org/position-papers/comparison/?domain=biodeg.org, and http://www.biodeg.org/files/uploaded/biodeg/Bioplastics_Mag-GS_article(6).pdf)

Some legislators have opted for an outright ban on plastic carrier-bags, but this is not a practical solution as the alternatives may be more damaging to the environment. (see http://www.biodeg.org/position-papers/Plastic-bag-bans/?domain=biodeg.org)

In the United States, On 27th January 2010 the California Court of Appeals refused to allow the City of Manhattan Beach to ban plastic bags without making a detailed Environmental Impact Assessment. They must now consider among other relevant factors whether a ban on plastic bags would increase the use of paper bags or would cause other damaging effects upon the environment.
See http://www.leagle.com/unsecure/page.htm?shortname=incaco20100127062 and
http://www.biodeg.org/position-papers/Plastic-bag-bans/?domain=biodeg.org

A better option is to require plastic bags and other plastic products to be degradable.

In some countries eg Ireland, a tax has been placed on all plastic shopping bags without distinguishing between degradable and non-degradable. This has benefitted the supermarkets, who no longer have to pay for so many bags, but it has led to an increase in sales of plastic garbage sacks, bin liners and other short-life plastic products. A large number of plastic products are still being sold in these countries, but there is no incentive to make them degradable.

Evidence from members of the Carrier Bag Consortium (who make and supply bin liners and refuse sacks) shows a plastic bag tax introduced in Ireland resulted in an increase of 300 - 500 per cent in the sale of plastic refuse bags and bin liners. They contain much more plastic than carrier bags.[87]

According to the UK Dept. for the Environment, Food, and Rural Affairs (The Guardian, 3 October 2007) "We don't think a ban or levy is the right way to go. In

[87] http://www.brc.org.uk/details04.asp?id=1109&kCat=&kData=263&sCat=Retail+Myths

Ireland, people just bought more bin liners to replace free carrier bags, so the volume of waste stayed the same".

PLASTIC BAG BANS

Plastic carrier bags are a wonder of modern technology. They can be made very thin, with minimal raw material, but are still strong enough to carry a full load of heavy shopping. No other shopping container can carry 2,500 times its own weight and stay strong when wet. A typical plastic carrier bag uses 70% less plastic today than 20 years ago. No other industry has a better track record in material reduction.

Plastic bags will protect the goods from dirt and rain, they are hygeinic and can be made in an almost unlimited number of colours and designs. Despite all these attributes they are very inexpensive, and are by far the most cost-effective and functional solution available.

The bags can also be re-used many times over for shopping, and are compact enough to be put in a pocket or handbag. They are also put to many other uses in the home, and for other uses such as clearing dog-waste from the streets, and most of them will eventually serve as a bin-liner to safely collect and dispose of household waste.

In some countries governments have been urged to ban plastic bags altogether, but an attempt to do so in Seattle USA has recently been rejected by its citizens.[88] A similar attempt by the City of Manhattan Beach, California, has been blocked by the Courts. They were finally allowed to proceed but only because of the small size of that community.

Q. Is it a good idea to ban plastic carrier-bags?
A. No.

Scientists and environmentalists have attacked a global campaign to ban plastic bags which they say is based on flawed science and exaggerated claims.[89]

The Times of London stated as follows in an editorial on 8th March 2008:

There is a danger that the green herd, in pursuit of a good cause, stumbles into misguided campaigns…. Analysis without facts is guesswork. Sloppy analysis of bad science is worse. Poor interpretation of good science wastes time and impedes the fight against obnoxious behaviour. There is no place for bad science, or weak analysis, in the search for credible answers to difficult questions….
Many of those who have demonized plastic bags have enlisted scientific study to their cause. By exaggerating a grain of truth into a larger falsehood they spread misinformation, and abuse the trust of their unwitting audiences.

Lord Taverne, chairman of "Sense about Science" said[90] *"This is one of many examples where you get bad science leading to bad decisions which are counter-productive. Attacking plastic bags makes people feel good but it doesn't achieve anything."*

On 18th February 2011 the UK Environment Agency published a Life-Cycle Assessment which highlighted that HDPE bags are, for each use, almost 200 times

[88] http://www.businessinsider.com/seattle-rejects-its-plastic-bag-tax-2009-8
[89] http://www.timesonline.co.uk/tol/news/environment/article3508263.ece
[90] Times 8 Mar 2008

less damaging to the climate than cotton hold-alls favoured by environmentalists, and have less than one third of the $C0_2$ emissions than paper bags.

The findings suggested that, in order to balance out the tiny impact of each lightweight plastic bag, consumers would have to use the same cotton bag every working day for a year, or use paper bags at least three times rather than putting them in the bin or recycling.

According to the UK Dept. for the Environment, Food, and Rural Affairs (The Guardian, 3 October 2007) *"We don't think a ban or levy is the right way to go. In Ireland, people just bought more bin liners to replace free carrier bags, so the volume of waste stayed the same".*

Because so many plastic bags are re-used for domestic waste disposal, the following increase in bin liners and refuse sacks occurred after the tax in Ireland:

- Tesco – 77% increase in pedal bin liner sales
- SuperQuinn – 84% increase in nappy disposable bag sales
- SuperValue/Centra – 75% increase in swing bin liner sales

(Evidence to Scottish Parliament, Environment and Rural Development Committee Hearings 2005).

On 8th November 2011 the Competitive Enterprise Institute of Washington DC published a paper on plastic bag bans[91] which concluded "Contrary to the rhetoric, plastic bans do not serve the environment, as they carry serious tradeoffs in terms of energy and water usage, and they do not solve problems associated with ocean litter. Policy makers who desire to address the real problem, which is litter, should look to existing programs that have a proven record of success. ….. Such policies may not offer the same opportunities for high-profile media coverage and credit claiming as do bans. They do, on the other hand, accomplish environmental goals without harming individual freedom, private enterprise, or the environment."

The case against plastic shopping bags is based on a number of fallacies:

Q. Plastic is made from oil or natural gas – is this not a finite resource which should be conserved?

A. Plastics are currently made from naphtha or ethane, which is a by-product of oil or natural gas. This by-product arises because the world needs fuels, and would arise whether or not the by-product were used to make plastic goods. So, nobody is extracting or importing extra oil and gas to make plastic. Until other fuels have been developed, it makes good environmental sense to use the by-product, instead of using scarce agricultural resources and water to make paper or cloth bags or vegetable-based plastic. In fact plastics could reduce the amount of oil and gas imported because after their useful life they can be incinerated to release the stored energy, which can be used to generate electricity or to heat buildings.

Q. But the landfills are filling up, and we need to reduce the amount of plastic bags going to landfill.

A. Plastic shopping bags occupy a tiny proportion of the space in landfill.

"0.2% of the average household dustbin is plastic carrier bags … hence a tax on plastic carrier bags alone would be unlikely to have any significant impact on volumes of waste" (Plastic Bag Tax Assessment, HM Treasury, UK, December 2002).

[91] http://cei.org/sites/default/files/Angela%20Logomasini%20-%20Plastic%20Bag%20Bans%20are%20Bad%20for%20the%20Environment%20-%20WebMemo.pdf

The fraction of landfill represented by plastic shopping bags is 0.05%. This is based on domestic waste being 17% of landfill and plastic bags being 0.2% of the average dustbin. (Packaging and Films Association 2007).

A far greater impact on landfill space would be made by diverting away from landfill bricks, concrete, wood, glass and other building materials and other items such as household appliances, which occupy much more space.

Q. But Plastic bags are getting into the open environment, where they will lie or float around for decades, killing wildlife and disfiguring the environment.

A. Plastic bags are so useful that for the forseeable future millions of them will be used every day all around the world. People should be educated not to litter but in no country will it be possible to collect and dispose responsibly of all the plastic. So all short-life plastic goods should be made with a technology which makes them self-destruct within a short time after their useful life if they get into the open environment (see www.biodeg.org).

Q. Surely long-term re-usable shopping bags are the answer?

A. Certainly not.
They are much thicker and more expensive, and a large number of them would be required for the weekly shopping of an average family.
30,000 jute or cotton bags can be packed into a 20-foot container, but the same container will accommodate 2.5 million plastic carrier-bags. Therefore, to transport the same number of jute or cotton bags 80x more ships and trucks would be required than for plastic bags, using 80x more fuel, using 80x more road space and emitting 80x more CO2.

Cloth bags are not hygienic[92] if a tomato is squashed or milk is spilled. Research by Guelph Chemical Laboratories in Canada in 2008 Microbiological Study of Reusable Grocery Bags[93] has shown that "re-usable grocery bags can become an active microbial habitat and a breeding-ground for bacteria, yeast, mold, and coliforms. …. The unacceptable presence of coliforms - ie intestinal bacteria, in some of the bags tested, suggests that forms of E.Coli associated with severe disease could be present in a small but significant proportion of the bags."

Whilst sometimes called "Bags for Life" they have a limited life, depending on the treatment they receive, and become a very durable form of litter when discarded.
Shoppers do not always go to the shop from home, where the re-usable bags would normally be kept, and consumers are unlikely to have a re-usable bag with them when buying on impulse items such as clothing, groceries, CDs, magazines, stationery etc. Research conducted for the Scottish Executive[94] carrier bag case studies showed that 92 per cent of people think re-using carrier bags is good for the environment but 59 per cent forget their re-usable bags and have to take new ones at the checkout!

[92] www.cpia.ca/epic/media/default.php?ID=2054
www.cpia.ca/files/files/A_Microbiological_Study_of_Reusable_Grocery_Bags_May20_09.pdf
http://network.nationalpost.com/np/blogs/theappetizer/archive/2009/05/20/back-to-plastic-reusable-grocery-bags-may-pose-public-health-risk.aspx

[94] http://www.scotland.gov.uk/Topics/Environment/funding-and-grants/carrier-bag-case-studies/Q/EditMode/on

As durable bags are a cost to the consumer and carrier-bags are a cost to the supermarket, one can easily understand why supermarkets are in favour of reducing the number of carrier bags and increasing the number of durable bags
However, for those who believe in long-term re-usable bags, they can be made from washable extended-life oxo-biodegradable plastic which will last for 3-5 years before they will harmlessly self-destruct, leaving no harmful residues.

Q. Isn't it better to use paper bags?

A. No.
"There have been unforeseen consequences in the Irish Experience … increase in the use of paper bags which are actually worse for the environment …" … Ben Bradshaw, UK Environment Minister, 4 August 2006.

The process of making paper bags causes 70% more atmospheric pollution than plastic bags. Paper bags use 300% more energy to produce, and the process uses huge amounts of water and creates very unpleasant organic waste. When they degrade paper bags emit carbon dioxide, and will emit methane in anaerobic conditions.

A stack of 1,000 new plastic carrier bags would be around 2 inches high, but a stack of 1,000 new paper grocery bags could be around 2 feet high. It would take at least seven times the number of trucks to deliver the same number of bags, creating seven times more transport pollution and road congestion.
Also, because paper bags are not as strong as plastic, people may use two or three bags inside each other. Paper bags cannot normally be re-used, and will disintegrate if wet.

In summary therefore it is not a good idea to ban plastic bags – it is a very bad idea