Degradable Plastics

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INTRODUCTION

Plastics have been an integral part of our lives for several decades in the form of convenient and useful commodity items. Plastic products are usually inert, chemically stable, resistant to corrosion, water-proof, durable and light-weight. Ironically, the same features which make them ideal as a raw material for such a wide range of products are also responsible for the environmental problems cited by many environmentalists. Furthermore, the fact that conventional plastics are derived from fossil fuels and are also responsible for greenhouse gas emissions during their manufacture is often a sore point. In particular, the plastic bag has in recent times come under attack for its prolific presence in the environment, and its impact on said environment.

Among the environmental concerns of plastic bags are the detrimental effects to marine creatures such as whales and turtles, which mistakenly ingest the plastic bag as food, and eventually die; the threat to coral reefs, which can be killed off as plastic bags surround and suffocate the corals; the risk of flooding which occurs when plastic bags are thrown in the streets as litter, and eventually block the drains; and the threat to public health, when carelessly discarded plastic bags trap stagnant water and create ideal breeding conditions for disease-spreading mosquitoes.

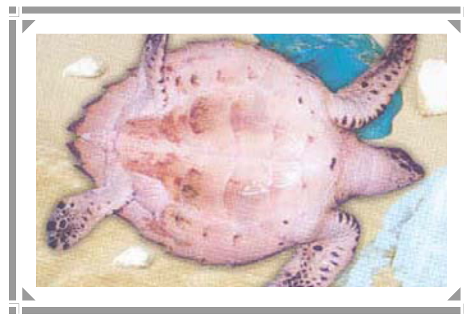

Photo credit: Secretariat of the Pacific Community

Degradable plastic bags were created to help solve the problems highlighted and they are often promoted as more ecologically, and environmentally friendly alternatives to conventional, non-biodegradable plastic bags. In fact, several countries have implemented taxes and levies to discourage the use of non-biodegradable plastic shopping bags and encourage the biodegradable option, and several more have imposed outright bans in order to reduce consumption and control the indiscriminate disposal of bags in the environment.

There is no denying that the negative impact of conventional plastic bags on the environment is real; the question is whether that negative impact can be reduced by using degradable plastic bags in place of the conventional plastic bags derived from fossil fuels. There is also a need to understand what other measures can be considered in developing a programme to reduce the environmental impact of plastic bags.

This paper provides information on degradable plastics and is intended to provide guidance on potential mechanisms for achieving reductions in plastic bag consumption. It is anticipated that this paper can be used in the Pacific region as a source of information, when trying to devise a strategy for dealing with plastic bags.

A BRIEF HISTORY OF PLASTICS

Conventional Plastics

Humans have enjoyed the benefits of natural plastics such as horn and tortoiseshell since ancient times. Horn which comes from a variety of animals such as cattle, sheep, and goats, and tortoiseshell derived from marine turtles, are likened to plastics because of their ability to be shaped when heated, and to retain that shape when cooled. Furthermore, natural shellac, which is the secretion of an insect on trees in the forests of India and Thailand, has also been used for thousands of years. It had a variety of applications such as being moulded into products (buttons, picture frames, boxes, toilet articles, jewellery), protective coating on wood floors, manufacture of phonograph records, among others.

Figure 1: Early 20th century French medal moulded from shellac

The first man made plastic was created from cellulose during the industrial revolution in 1862 and was called Parkesine. In 1868, celluloid was created as a substitute for ivory billiard balls, and is still used today to manufacture table tennis balls. Celluloid also became popular as a flexible film used for still photography and motion pictures. The discovery of several other plastics, such as Bakelite, cellophane and PVC followed these initial discoveries, and in 1933, two organic chemists accidentally discovered polyethylene, the basis of numerous modern-day products including the plastic shopping bag. Other commonly known plastics were also invented in subsequent years: polystyrene (PS) in 1938, high density polyethylene (HDPE) in 1951, and polypropylene (PP) in 1951. Another form of PS known by the trademark Sytrofoam, was developed in 1954 and finds uses in foam cups, plates, packaging and insulating materials [American Chemistry Council, 2008; Bells, 2008; The Society of the Plastics Industry, 2008] .

Plastic bags are reported to have been first introduced in 1957 as sandwich bags [Sentimental Plastics, 2008]. Subsequently, there has been an explosion in their use to the extent that billions of bags are used daily worldwide. Common estimates for global use of plastic bags available from the World Wide Web, place the figure at between 500 billion and 1 trillion plastic bags annually (that's over 1 million bags per minute!).

Degradable Plastics

During the 1980s, the United States experienced a "solid waste crisis" and plastics were often seen as a particular problem because they are non-biodegradable. Degradable plastics are a new and emerging type of plastics created within recent times in response to the landfill crisis. It was originally thought that the crisis could be averted if more wastes could be made to degrade [Andrady, 2003]. The degradable plastics first produced targeted the disposable markets with products such as garbage bags, snack food wrappers, and disposable plates, and were intended to address litter and reduce landfill waste.

CLASSIFICATION OF PLASTICS

1. Conventional Plastics

A classification of the common types of conventional plastics is shown in Figure 2.

FIGURE 2: Types of commodity plastics

Source: *The Categories of Plastics.* Available from www.fresno.gov

CLASSIFICATION OF PLASTICS

2. Degradable Plastics

Types

Several types of degradable plastics are available on the market today; each type reacts differently to its disposal environment and degrades by different mechanisms. The various types can be classified in two ways: (i) based on the method by which they degrade (degradation pathway), for example by microbial action, using heat, ultraviolet light, mechanical stress, or water; and (ii) based on their composition, for example whether they are made from naturally-derived (i.e., corn-, potato-, wheat-derived) starch polymers, from conventional polymers, or from blends of both [ExcelPlas Australia, et al., 2004].

The classification used in this document and summarized in Table 1 is based on the first method of degradation pathway. There are four methods by which plastics can degrade, they can be biodegradable, oxo-biodegradable, photo-degradable, or water soluble.

Biodegradable Plastics

Biodegradable plastics are plastics which can be broken down by biological agents, specifically micro-organisms. They decompose to produce carbon dioxide, methane, water, and inorganic compounds also known as biomass. Biodegradable plastics can be made from thermoplastic starch (TPS), polyesters, and blends of TPS and polyesters.

TPS-based biodegradable plastics

Thermoplastic starches are based on gelatinized starch produced from potato, corn, wheat or tapioca. There are essentially three categories of TPS-based biodegradable plastics:

i. The first category consists of the TPS combined with additives such as plasticizing agents to provide plastic-like properties.

ii. TPS can also be blended with synthetic polymers which are hydrophilic (water-loving) such as polycaprolactone. The synthetic element improves the strength of the resulting plastic.

iii. The third category is primarily conventional, non-biodegradable plastics such as polyethylene blended with small quantities of TPS. The TPS degrades and causes the fragmentation of the conventional plastic into small particles, which may still persist in the environment for many years.

Biodegradable polyesters

These biodegradable plastics can be synthesized from renewable resources using biotechnology, and include polyhydroxybutyrate (PHB) and polylactic acid (PLA). Biodegradable polyesters can also be produced from fossil fuels, and include polycaprolactone (PCL), and polybutylene succinate (PBS).

Oxo-biodegradable Plastics

Conventional plastics in their regular form are known to take decades to degrade because of their stable chemical structure. Oxo-degradable plastics are built on the backbone of conventional plastics (such as polyethylene) and incorporate additives that break down when exposed to natural daylight, heat and/or mechanical stress. Manufacturers report that the break down of additives causes the fragmentation of the plastic into smaller pieces, with chemical structures that make them more accessible to biodegradation by micro-organisms.

The term "photo-degradable" may also used to refer to oxo-degradable plastics which contain ultra-violet (UV) sensitive additives that break down on exposure to daylight or ultra-violet light.

The reported benefit of oxo-degradable plastics is the ability to 'program' the shelf-life of products made from this material. After the designed life, then the additives begin to react to the environment (heat, light, or mechanical stress) and initiate the fragmentation process. At this time, it is unclear whether or not this secondary biodegradation of fragmented plastic actually occurs.

Water Soluble Plastics

Water soluble plastics refer to that category of plastics that simply dissolve in water over a given temperature range and can then further biodegrade in the presence of micro-organisms.

Table 1 categorizes the various types of degradable plastics based on composition as well as degradation pathways.

Table 1: Types of Degradable Plastics (adopted from Excel Plas Australia, et al., (2004)

COMPOSITION	COMMERCIAL EXAMPLES	TYPICAL APPLICATIONS	DEGRADATION TIME
Biodegradable thermoplastic starch blended with synthetic polymers			
Thermoplastic starch derived from corn, potato or wheat, blended with additives (e.g. plasticizers)	Novon, Eco-FOAM	Shopping bags, bread bags, take-away food containers, loose fill packaging	Unknown
Thermoplastic starch derived from corn, potato or wheat and blended with naturally-derived polyesters (e.g. PLA) or with synthetic polyesters (e.g. PCL)	Mater-Bi, BioFlex	High quality sheets and films for packaging and other film applications	Soil: 8 weeks Water: more than 30 weeks Compost: 1-2 months
Thermoplastic starch derived from tapioca, corn, potato or wheat, and blended with polyethylene	Polystarch N , Entec, Environmentally Degradable Plastic	Film applications including plastic bags	Soil: 1-4 weeks with accelerated conditions Compost: 2-14 months (depends on starch content)
Thermoplastic starch derived from corn, blended with PVOH	Plantic, Biograde	Loose fill packaging	Unknown
Biodegradable polyesters			
Polybutylene succinate (PBS)	Sky Greenä, Bionolle	Fibers, films, bottles, and cutlery	unknown
Poly (butylenes succinate-co-adipate (PBSA) copolymers	Sky Green	Food containers & packaging, detergent and shampoo bottles	Unknown
Polybutyrate adipate terephthalate (PBAT)	Bionolle		Unknown
Adipic acid aliphatic/aromatic copolyesters (AAC)	Eastar Bio, Ecoflex	Cling film, film bags	Unknown
Polylactic acid (PLA)	Nature-Works, Lucty, Eco Plastic	Films, sandwich and fruit trays, short-life bottles	Soil: Compost: 2 – 6 weeks
Polycaprolactone (PCL)	Tone, CAPA, Celgreen	Food-contact foam trays, loose fill, film bags	Water: 8 weeks (in the sea)
Polyhydroxy-butyrate-valerate (PHB/V)	Biopol, Biocycle	Bottles and plastic films for packaging	Unknown
Oxo-degradable polymers			
Polyethylene with a thermal and/or UV prodegradant additive	Addiflex , PDQ Degrade, , Bio-Solo, Entec	Same applications as polyethylene (films,	Soil: 6 weeks Compost: 2 weeks – 18 months Landfill: 5-10 years
Water soluble polymer			
Polyvinyl alcohol (PVOH) and ethylene vinyl alcohol (EVOH)	Vinex, Elvanol, Poval, Exceval, Hi-Selon	Film applications, oxygen barrier layer in multi-layer film packaging	Unknown
Photodegradable polymers			
Thermoplastic synthetic polymers or copolymers	EcoLyte	Films, plastic beverage rings	Unknown

CERTIFICATION SYSTEMS

There are many definitions for biodegradability and consequently not all products that claim to be biodegradable will behave in the same way. Certification systems introduce objectivity and refer to measurable performance standards, which essentially measure the biodegradability and compostability of products. A product certified to a given standard essentially guarantees that the product will biodegrade under conditions specified in the standard. Several certification systems have been developed with distinct logos that make compliant products easily recognizable as shown in Table 2. These systems are based on the standards detailed in Appendix A. It is strongly recommended that biodegradable products be purchased only from certified sources.

TABLE 2: Certification for compostability

kompostierbar

This logo is owned by DIN-Certco of Germany

It certifies products tested for compostability under these standards: DIN V54900, EN 13432 , and ASTM D6400-99

OK compost VINÇOTTE — SOIL OK bio-degradable VINÇOTTE — WATER OK bio-degradable VINÇOTTE

This family of logos belongs to the quality control organization, AIB-Vincotte International (AVI) in Belgium

The OK compost mark guarantees that the product bearing the mark can be composted in an industrial plant or in a household compost pile. A list of complaint products can be found at: http://www.vincotte.be/Frontmodules/pdf/okc-mate.pdf

The OK Biodegradable Soil, and OK Biodegradable Water certifies that that the material in a product bearing the mark is biodegradable in soil or water (fresh and sea) respectively. A list of certified products can be found at: http://www.vincotte.be/Frontmodules/pdf/okb-mate.pdf

This logo is owned by the Biodegradable Products Institute (BPI) in the USA. It certifies products based on the ASTM D6400-99 standard. A list of certified products can be found at:

http://www.bpiworld.org/BPI-Public/Approved.html

COMPOSTABLE Biodegradable Products Institute | US COMPOSTING COUNCIL

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The GreenPla logo is a symbol for the certification system started by the Japan BioPlastics Association (JBPA). It certifies products meeting standards specified by the JBPA, many of which are similar to ASTM and ISO standards

A list of certified products can be found online at: http://www.jbpaweb.net/english/e-gp-products.htm

COSTS AND BENEFITS OF PLASTICS

1. Environmental Costs

Degradable plastics are often promoted as a better, more environmentally-friendly alternative to conventional plastics, but is that really the case? It's very difficult to provide a simple answer to that question since there are many environmental costs and benefits associated with both types of plastics. Moreover, the science of degradable plastics is relatively new compared to the conventional plastics, and there are undoubtedly significant developments yet to be made. The following section will provide an overview of the potential positive and negative impacts of degradable plastics.

Degradation process

By definition, degradable plastics are made to degrade under the right conditions; however, if managed poorly, this intended benefit can be detrimental.

- On land, if biodegradable plastics are placed in landfills, they are essentially contributing to the organic loading of the landfill, which is the main cause of leachate and landfill gas production. Degradation of all organic matter is also significantly slower in anaerobic landfills, so that any intended benefit of biodegradability becomes lost.

- In the aquatic environment, degradation of materials containing high nutrient contents can lead to algae blooms and eventually to the death of fishes and other aquatic life. This process is known as eutrophication. Starch-based biodegradable plastics, which are used to make plastic bags, can have high nutrient contents and lead to eutrophication if disposed of in the aquatic environment; whereas conventional plastics are inorganic, stable, do not have nutrient content and can take decades to degrade in water.

Leaching of harmful chemicals

Degradable plastics contain a range of additives including dyes, plasticizers, catalyst residues, coupling agents, fillers, and sometimes pro-degradants (additives which break down under ultraviolet, heat, or mechanical stress), many of which may be toxic. These compounds are released when the plastics degrade and can also leach out of the plastic very slowly over time.

- If the plastic is composted, then the degradation by-products will be released into the finished compost. The tainted compost, when used, will expose plants, soil organisms, and aquatic environments to these by-products.

- If the plastic ends up in the aquatic environment, then the degradation by-products can cause the death of aquatic life. Some by-products may also bio-accumulate in certain species and affect humans, who eventually consume the affected species.

Conventional plastics also contain various chemicals which are considered harmful to human health and the environment when leached. The chemicals found in some commodity plastics are shown in Table 3. The conventional plastics (LDPE, HDPE) from which plastic bags are produced appear not to leach harmful chemicals compared to the other plastics shown in the table.

TABLE 3: Toxic ingredients in common plastics

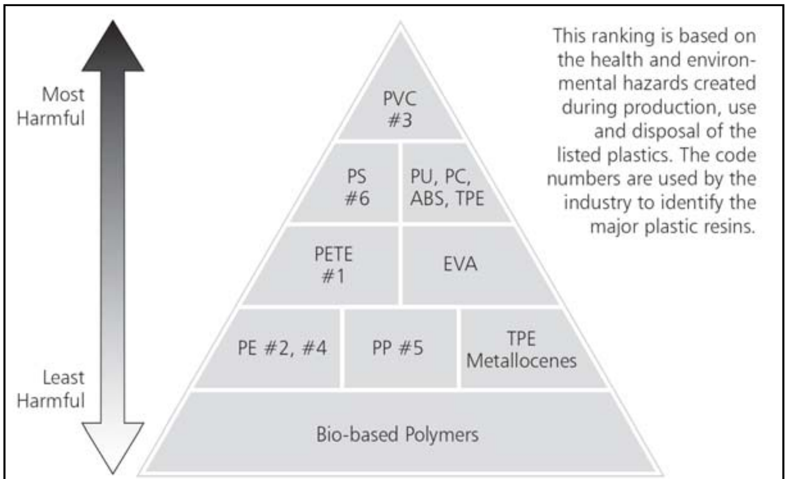
Plastic	Typical use	Potentially toxic ingredients
Polyethylene terephthalate (PET)	Plastic bags, water and soda bottles, food containers and wrappers	Acetaldehyde
Polyvinylchloride (PVC)	Commercial grade cling wrap,	Lead, cadmium, mercury, nonylphenol, diethylhexyl phthalate (DEHP), Bisphenol A (BPA)
Polystyrene (PS)	Food containers, foam products (cups, plates), disposable cutlery, foam packaging	Styrene
Polycarbonate	Water bottles	Bisphenol A

Source: Ecology Center. 2009?. Adverse Health Effects of Plastics. Available from <http://www.ecologycenter.org/factsheets/plastichealtheffects.html> Accessed March 10, 2009.

Belliveau and Lester (2004) used a Plastics Pyramid to demonstrate the ranking of the major types of plastics in terms of the toxic chemical hazards (to health and the environment) associated with the production, use and disposal of the plastics. This pyramid is reproduced in Figure 3. This particular representation supports the view that biodegradable plastics pose less of a chemical hazard than many of the common conventional plastics.

Figure 3: A Plastics Pyramid

Source: Belliveau and Lester (2004)



A key to the plastics and some hazards associated with production, use and disposal

Level 1	PVC = Polyvinyl chloride	Chlorine, intermediates, many additives, byproducts
Level 2	PS = Polystyrene	Intermediates, fewer additives, some byproducts
	PU = Polyurethane	Some chlorine used, intermediates, waste byproducts
	ABS = AcrylonitrileButadieneStyrene	Hazardous intermediates, difficult to recycle
	PC = Polycarbonate	Some chlorine used, intermediates, toxic solvents, BPA
	TPE = Thermoplastic Elastomer	A copolymer or alloy of conventional plastic
Level 3	PETE = Polyethylene terephthalate	Some hazardous chemicals, high recycling rate
	EVA = Ethyl vinyl acetate	Chloride catalyst, some byproducts
Level 4	PE = Polyethylene	Fewer additives, some byproducts, high recycling rate
	PP = Polypropylene	Fewer additives, some byproducts
Level 5	Bio-based Polymers	Naturally based, e.g. starch, cellulose; compostable

Litter

On land, litter in the form of light plastic films and bags is a visual blight on the landscape and is often windblown, caught up caught in trees and bushes, or thrown in drains, ditches and rivers. Furthermore, plastic litter can trap water that becomes stagnant and a perfect breeding ground for disease-transmitting mosquitoes.

- There's unlikely to be sufficient bacteria in trees and bushes to cause biodegradation of wind-blown litter. If the bags degrade through UV exposure, there will still likely be visible fragments of plastic for some time, until they eventually biodegrade or weather away.
- Also on land, plastic litter can end up in drains and ditches causing blockages and leading to floods during heavy rains. In turn, the flooding can cause significant property damage. Unless they are water soluble, degradable polymers are unlikely to break down quickly enough (see Table 1) to be of much help in preventing the blocking of drains – especially during the rainy season, when torrential rainfalls are frequent.

In the ocean, plastic litter is often mistakenly ingested as food by marine animals, such as turtles and whales. The plastic blocks the animal's digestion system and leads to starvation. Although water-soluble plastics degrade in water, it is unlikely that many of the other types of degradable plastics will degrade rapidly enough in the sea or the animal's stomach to prevent injury to the animal.

These problems may potentially be compounded if the concept of biodegradable plastic is poorly understood, and there is increase in plastic litter by consumers who believe the plastics will disappear very quickly.

Contamination of recycling streams

Degradable plastics as the name suggest are designed to break down in the environment and are not intended for recycling. There could be severe negative impacts on the recycling of conventional plastic waste if that waste is contaminated with degradable plastics. Nolan-ITY Pty Ltd (2002, p. iii) in their characterization of emerging issues associated with biodegradable plastics in the Australian market identified that:

> "The risk of contamination by biodegradable plastics of conventional plastics which are currently recycled and reprocessed is a significant one, and the resultant effects on recyclate has the potential to undermine the growing confidence in recycled plastics. Effective methods for sorting biodegradable plastics would be needed in the event of their significant entry into the Australian market"

The most significant potential for impact is in the area of plastic film recycling, where the technology for separation of conventional plastic films from degradable films has not been fully realized. While plastics recycling in the PICTs is limited to collection, packaging and export of the material, potentially negative ripple effects include lower prices for recyclable plastics contaminated with degradable plastics, and higher labour costs to achieve better separation of the plastic types.

Plastic Foams

The production process for certain types of plastic products involve the use of environmentally harmful chemicals. For example, the production of plastic foam products, such as packaging peanuts, and foam cups and plates involve the use of chlorofluorocarbons (CFCs) which are known to deplete the ozone layer. Within recent times and as a result of the Montreal Protocol, which calls for the elimination of substances that deplete the ozone layer, efforts have been made to replace the CFCs with chemicals that break down before reaching the ozone layer, such as hydrofluorocarbons (HFCs) and hydrofluorocarbons (HFCs), and even carbon dioxide (CO_2). However, the disadvantage of these alternative chemicals is that they also act as greenhouse gases, and contribute to global warming.

Chemicals will be used in the production of plastic foam products regardless of the source of the plastic (biodegradable, or conventional), consequently, the best means of avoiding this negative impact is to reduce the consumption of plastics.

2. Economic Costs

The plastics manufacturing industry in the Pacific region is limited to the processing of plastics imported in pellet form, to create consumer products such as plastic bags. Meanwhile, all PICTs import and use consumer products made of some type of plastic, with the most common being the plastic bag. Conducting a cost analysis is a good way of determining the financial impact of introducing degradable plastics into circulation. Such analysis should consider, where applicable, the cost of degradable plastic resin (raw materials) that will be used to manufacture degradable products like plastic film; the cost of upgrading manufacturing facilities (if they exist); and of course, the cost of importing degradable products.

This document does not provide a cost analysis. A limited list of suppliers of certified biodegradable plastic bags has been provided in Appendix B, from which the cost of supplying degradable plastic products can be obtained. Additional certified suppliers for other products such as food packaging, films, etc., can be obtained from the web-links provided in Table 2 (see Certification Systems).

In terms of the wider economic costs, such as impacts on other developmental areas such as tourism, fisheries, etc., they are likely to be the same for both degradable and non-degradable plastics. The reason for this is because the rate at which plastic is indiscriminately disposed as litter is greater than the rate at which it could ever degrade. The net effect therefore is of constant litter and subsequent accumulation in the environment, causing the environmental problems already discussed.

3. Environmental Benefits

Composting

The compost derived from the right type of biodegradable plastics is an important soil amendment that increases organic carbon, as well as water and nutrient retention abilities of soils, while reducing the need for fertilizers and suppressing plant disease [Ref. Australian report]. Within the Pacific Islands, especially atolls, compost is a much needed product, as atoll soils tend to be porous, dry, and lacking in humus.

Landfill degradation

As mentioned during the discussion of negative environmental impacts, biodegradable plastics buried in landfills, contribute to the organic loading of the landfill. If landfill gas (methane) is harvested for energy, then this point becomes a positive, since increased organic loading leads to greater production of methane.

Energy use & greenhouse gas emissions

Some scientific publications report that the energy required to synthesize and manufacture biodegradable plastics is lower than for similar conventional plastics (see Table 4 for a comparison). Furthermore, since energy is closely tied to greenhouse gases (GHG), emissions over the life of a biodegradable plastic are reported to be less than for similar conventional plastics.

In the Pacific islands, the energy use and GHG emissions would not normally be deciding factors, since these countries are consumers and not synthesizers or manufacturers of biodegradable plastics. However, it is still important to understand how the different plastics stack up. Based on current climate change concerns, and the push for less energy-intensive processes, the plastics requiring less energy, and causing less GHG emissions will be more likely to succeed in the long-term.

Tab le 4: Energy use and greenhouse gas (GHG) emissions for several plastics

Plastic type	Non-renewable energy use (Mega-Joule/kg of product)	GHG emissions (kg CO_2 equivalent)
HDPE	79.9	4.84
LDPE	80-92	5.04-5.20
Polycaprolactone (PCL)	77-83	3.1-5.7
Polyvinyl alcohol (PVOH)	59-102	2.7-4.3
Thermoplastic starch (TPS)	25	1.14-1.20
PLA	57	3.84
PHB (various processes	66-573	Not available

Source: Patel, M. 2003. In E. Chielini and R. Solaro, (eds). *Biodegradable Polymers and Plastics*. New York: Kluwer Academic/Plenum Publishers.

REDUCING PLASTIC WASTES

1. Options

The previous section illuminated some of the positive and negative environmental impacts associated with conventional and degradable plastics. It is important to note that making the decision to replace one type of plastic with another does not address the behavioural change which is needed to reduce the amount of plastic wastes being produced and to reduce the littering and poor disposal practices which are so prevalent. This section provides some practical options, which can be implemented to achieve reduction in plastic wastes.

As mentioned previously, plastic waste can create a multitude of environmental problems with spin-off implications for public health, tourism, and agriculture. There are several options available to either achieve a reduction in plastic bag consumption, or to reduce the environmental impact of plastic bags. The most successful tool will depend on the specific social, economic, and political conditions existing in the country and will likely involve a combination of the measures listed below, and which are discussed in this section.

- Command and control approach
- Economic instruments
- Voluntary measures

Command and Control Approach

The use of the command and control (CAC) approach involves the use of direct regulation such as standards, permits and licenses (command), along with monitoring and enforcement systems (control). In most cases, the CAC approach enables the regulator to have some degree of predictability about how much pollution levels will be reduced (Bernstein 1991).

The CAC approach applied to the plastic bag issue mainly translates into passing legislation that bans the importation and use of plastic bags. Banning the importation and use of plastic bags is a drastic step which several countries have adopted. For example, Bangladesh imposed an outright ban on thin plastic bags in the capital city of Dhaka in 2002; while in India, Mumbai banned plastic bags in 2000. A ban would lead to a major reduction in plastic bag litter and waste management costs. However, at the same time, there would be an economic impact on the plastic bag industry comprising manufacturers, importers, recyclers, and their employees.

- A ban was successfully used by Samoa in 2006 to ban the importation and use of non-biodegradable plastic bags. This ban encourages the use of biodegradable plastics. A copy of Samoa's legislation can be provided on request.

- Papua New Guinea Government tried to use a CAC approach in 2005 to ban the use of plastic bags, however, they were barred from doing so by a court ruling in favour of two major plastic bag manufacturers – Colorpak Ltd, and W.H. Industries Ltd. Colorpak Ltd reported that a ban on plastic bags would cause the closure of their business, job losses and argued that the proposed ban contravened investment laws and the constitution [Red Orbit, 2005].

As the name implies, a CAC approach cannot be successful without monitoring and enforcement.

In the case of plastic bags in the pacific, enforcing a ban on the importation of certain types of plastic bags can be easily monitored at the point of importation. However, because a biodegradable plastic is not easily distinguished from a degradable plastic with the naked eye, it is critical that products be acquired from suppliers or manufacturers who have been certified under some international standard (see section on Certification Systems).

Economic Instruments

Economic instruments (EI) refer to a set of tools that makes use of monetary incentives and deterrents in addition to market measures in order to influence behaviour. In the solid waste management context, they provide a country with the means to control the generation and disposal of solid wastes.

EI can be broadly classed into three categories according to the purpose: (i) revenue-raising instruments – these instruments raise capital to cover operational costs and fund waste management programmes; (ii) revenue-providing instruments – these provide incentives to encourage desirable and responsible behaviour; and (iii) non-revenue instruments – these combine a fee, with a subsidy, which negates the fee when the desired disposal behaviour occurs. More information can be found in the detailed guide, "The Application of Economic Instruments to Solid Waste Management in Pacific Island Countries and Territories" , produced by SPREP (2009).

In relation to plastics, economic instruments most often take the form of taxes applied at the point of use. For example, in the case of plastic bags, Ireland passed laws in 2002, requiring all stores, supermarkets, etc., to charge customers a levy for each bag used. When introduced in 2002, the levy was approximately US$0.15, and subsequently, there was a reduction in plastic bag consumption of 94% (BBC News, 2003). Today, the tax stands at about US$0.33 per bag and all money from the tax goes directly to the environment ministry for use in enforcement and clean-up projects.

Several other countries, such as Italy, Belgium, Germany, and Switzerland have also put similar laws in place. Refer to Appendix C for a snapshot of how other countries around the world are dealing with plastic bag

Voluntary Measures

Voluntary measures are those activities and measures implemented, usually by the private sector, but which are not legally-binding. In terms of the plastic bag, voluntary measures to reduce consumption of bags can include:

- Alternative bag trials
- Voluntary levies
- Codes of practice
- Collection for recycling
- Community awareness and education

1. Alternative bag trials

Alternative bag trials involve offering alternative and reusable bags, such as calico or cotton bags, or biodegradable bags at reasonable and attractive prices. This approach has been used in both Samoa and Kiribati (see pictures). In Samoa in 2006, SPREP in conjunction with ANZ Bank launched a turtle-bag campaign which saw the sale of reusable shopping bags as part of a larger awareness campaign on the impacts of plastics to marine turtles. In Kiribati, a voluntary initiative by an association of people with disabilities resulted in the production of 2000 reusable poplin bags which were distributed during a national games event.

Poplin reusable bags produced in Kiribati

Samoa Government and SPREP officials at Turtle Bag Campaign launch

Alternatives such as reusable cotton bags, paper bags, and traditional bags like the bilum bag of Papua New Guinea provide consumers with practical alternatives that can help to discourage the use of thin plastic bags. Figure 4 shows a whole range of alternatives that can be used in place of a disposable plastic bag.

FIGURE 4: Alternatives to disposable plastic bags

Paper bags

Cardboard box

Plastic crate

Trolley Bag

Coconut basket (used in Fiji, Samoa, and other Pacific countries

Bilum bag (used in Papua New Guinea)

Reusable bags (cotton, polypropylene, nylon)

2. Voluntary levies

Usually, the cost of providing plastic bags to customers is included into the cost of whatever goods are being sold. Consumers perceive that the bags were given to them for free, although they have paid indirectly. Imposing voluntary levies would involve supermarkets, stores, etc., exposing the true cost of the plastic bag to consumers, so that they pay directly for the quantity they use, and thereby become more aware of the cost.

In order for voluntary levies to work successfully, a reasonable alternative to the levied item (in this case, plastic bag) must be provided – reusable bags, paper bags etc. Also, it is important that there is wide participation by the private sector in the voluntary scheme. For example, if only a few supermarkets or shops tax plastic bags, this might cause consumers to shop at competitors who have not imposed the tax, thereby creating an unfair disadvantage. Voluntary measures must also be implemented as part of a wider education campaign, educating consumers on the reasons for the levy.

In Victoria, Australia, three regions took part in a 4-week trial to implement a 10-cent charge on individual plastic bags. After the trial an average reduction of 79 percent in plastic bag consumption was reported. This was accompanied by a surge in sales of reusable bags during the first week as consumers bought the bags and used them over subsequent weeks. Interestingly, the study reported that only 3% of consumers were willing to go elsewhere in order to avoid paying the charge. One of the main conclusions of that study was that a permanent 10-cent charge would likely contribute to a long-term change in customer behaviour (KPMG, 2008).

3. Codes of Practice

A code of practice is a voluntary measure which sets out broad guidelines for signatories to follow. It is not legally binding and is self-regulated. Codes of practice are beneficial in that they do not require drafting and enacting of legislation, which can at times be a lengthy process. However, unless the signatories are genuinely committed and are self-motivated to adhere to the codes, the codes become effectively useless.

In Australia, the Code of Practice for Supermarket Carry Bags was launched in 1997, and signatories consisted of supermarkets. The code calls for signatories to implement eight actions based on the waste hierarchy, and aimed at reducing, reusing and recycling plastic shopping bags, monitoring their use, and reporting results annually. As noted in a report on plastic shopping bags in Australia (National Plastic Bags Working Group, 2002), many of the commitments required under the code are broad, and rely on the knowledge and ability of in-store staff. Success during implementation will therefore be varied. In December 2004, the Australian Retailers' Association (ARA) reported that signatories to the Code of Practice had achieved a combined reduction of about 27% in plastic bag consumption (ARA, 2004).

Australia also has another voluntary agreement called the National Packaging Covenant, which manages the environmental impacts from packaging waste (including plastics). Signatories are required to take specific actions to reduce the effects of packaging on the environment throughout its life cycle – from design and production to disposal. The Covenant is backed by legislation to ensure that Covenant signatories are not disadvantaged in the market place. The legislation is called the National Environment Protection (Used Packaging Materials) Measure (NEPM). Non-signatories to the Covenant are regulated under the NEPM, which sets more stringent performance targets for recovery of packaging material, as well as more burdensome reporting obligations than under the Covenant.

4. Collection for recycling

Collecting plastic bags for recycling is mostly done in developed countries where infrastructure exists for collection and recycling. For example, in Canada about half of the population has access to recycling through a combination of curbside programmes, drop-off depots or take-back programmes operated in some stores. Collected bags are then recycled into other consumer products such as plastic furniture, signage, etc.

In Samoa a joint initiative involving Corporate Recycling Pty Ltd (now Repeat Plastics Australia - Replas), and Australian Arrow Pty Ltd (formerly Yazaki Australia), and the Samoan Government, was undertaken in 2006. Under this initiative, Samoa ships its plastic waste to the Replas processing plant in Victoria, Australia where it is recycled and converted into sustainable products such as plastic furniture, signs, etc, to be exported back into Samoa. This arrangement is beneficial for all parties, and is crucial in helping Samoa to manage its plastic waste. It is possible that there may be future scope for establishing a dedicated recycling operation in Samoa, and it is further hoped that this arrangement could serve as a model for the region.

To assist in the operation of this programme, Samoa has established a series of collection bins for plastic waste throughout the city of Apia and other outlying areas.

5. Community awareness and education

Community awareness and education is an integral component of each tool discussed above. It is important that the general public understands the aims and objectives of different programs, so that they would be more willing to participate. Implementing changes without consultation and appropriate awareness/education is a recipe for disaster.

Appendix C provides an overview of some of the measures that are being taken by countries around the world, to reduce the consumption and impacts of plastic bags.

REDUCING PLASTIC WASTES

2. Next Steps

The decision to act in order to reduce the generation and indiscriminate disposal of plastic wastes is an important one. There is no single approach that can be used – this will vary depending on the particular social, economic, and political conditions in the country.

A simple generic strategy, which has been formulated using information provided in this document, and which can be used as a template for creating your own national strategy, is provided in Appendix D Formulating a workable strategy demonstrates clear intentions and provides a road map on actions to be taken to achieve progress on the management of plastic wastes, in particular plastic bags.

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APPENDIX A:

International Standards for Biodegradable Plastics

Standards for bio-degradability

There are no standards within the Pacific region that govern biodegradable plastics. Several international standards exist, and it is important that any claims of product degradability comply with at least one of these standards. This may be the only guarantee one has that a product marketed as degradable, will degrade (at least under the test conditions specified in the standards). The main international organizations that have produced standards or testing methods are:

- American Society for Testing and Materials (ASTM) (www.astm.org)
- European Standardisation Committee (CEN) (www.cenorm.be)
- International Standards Organization (ISO) (www.iso.org)
- German Institute for Standardisation (DIN)
- Standards Australia (AS) (www.standards.org.au)

The following table summarizes the international standards available from some of these organizations and their interpretations. The standards referred to in the table specify test conditions and procedures that must be followed to determine the biodegradability of materials in certain environments.

TABLE A.1: Summary of international standards for biodegradability

Test Conditions	ASTM	ISO	CEN
Aerobic biodegradation under controlled composting	D5338-93	14852	14047
Anaerobic biodegradation in aqueous system	D5210-92	ISO/DIS 14853	N/A
Aerobic biodegradation in aqueous medium (e.g. activated sludge wastewater treatment system)	D5271-02	14851	14048
Anaerobic biodegradation in a high-solids anaerobic digestion conditions (e.g., a solid waste digester)	D5511-02	ISO/DIS 15985	N/A
Aerobic biodegradation in soil	D5988-03	17556	N/A
Aerobic biodegradation in marine environment	D6691-01	N/A	N/A

Standards for compost-ability

Due to the complex nature of biodegradable plastics, and a need to ensure that the compost end product is high-quality and not contaminated with bits of plastic, the biodegradation of a plastic material is not a sufficient condition to ensure its overall compostability. Instead, three basic conditions must be fulfilled:

1. Biodegradation: the plastic should break down completely into mineral end products (carbon dioxide, water) and biomass.

2. Disintegration: visually, the plastic should fall apart and disintegrate into particles that cannot be seen with the naked eye.

3. Compost quality: the plastic being composted should not negatively affect the quality of the compost end-product.

There are three main standards for evaluating the compostability of biodegradable plastics (referred to as composting norms). These are the EN 13432, DIN V54900, and ASTM 6400. The main differences between these three standards are summarized in Table A.2. A biodegradable plastic which has been tested under these standards should clearly state the standard for which it is certified.

TABLE A.2: Standards for determining compostability

Condition	Composting norm			
	EN 13432	DIN V54900	ASTM 6400	Japan Standard
Material characteristics	Organic matter content should be at least 50% of the weight (or volume) Maximum concentrations specified for 11 heavy metals	Organic matter content should be at least 50% of the weight (or volume) Maximum concentrations specified for 7 heavy metals	Maximum concentrations specified for some heavy metals	Organic matter content should be at least 50% of the weight (or volume) Maximum concentrations specified for 9 heavy metals
Bio-degradation	90% biodegradation in 6 months	Homopolymers*: 60% bio-degradation in 6 months Heteropolymers**: 90% in 6 months	As for DIN V54900	60% mineralization in 6 months for each polymer component.
Disintegration	Less than 10% of the original weight should be measurable in screened compost greater than 2 mm			
Compost quality	Compost containing degraded plastic should show same plant germination and growth rates as compost without degraded plastic As for EN 13432 As for EN 13432			Compost containing degraded plastic should show at least 90% of the plant germination and growth rates as obtained with compost without degraded plastic

* Homopolymer refers to a polymer or plastic comprised of a single monomer (e.g. polylactic acid)

** Heteropolymer refers to a polymer made of two or more monomers (e.g. polyhydroxybutyrate-co-valerate)

APPENDIX B:

Suppliers of certified biodegradable plastic bags

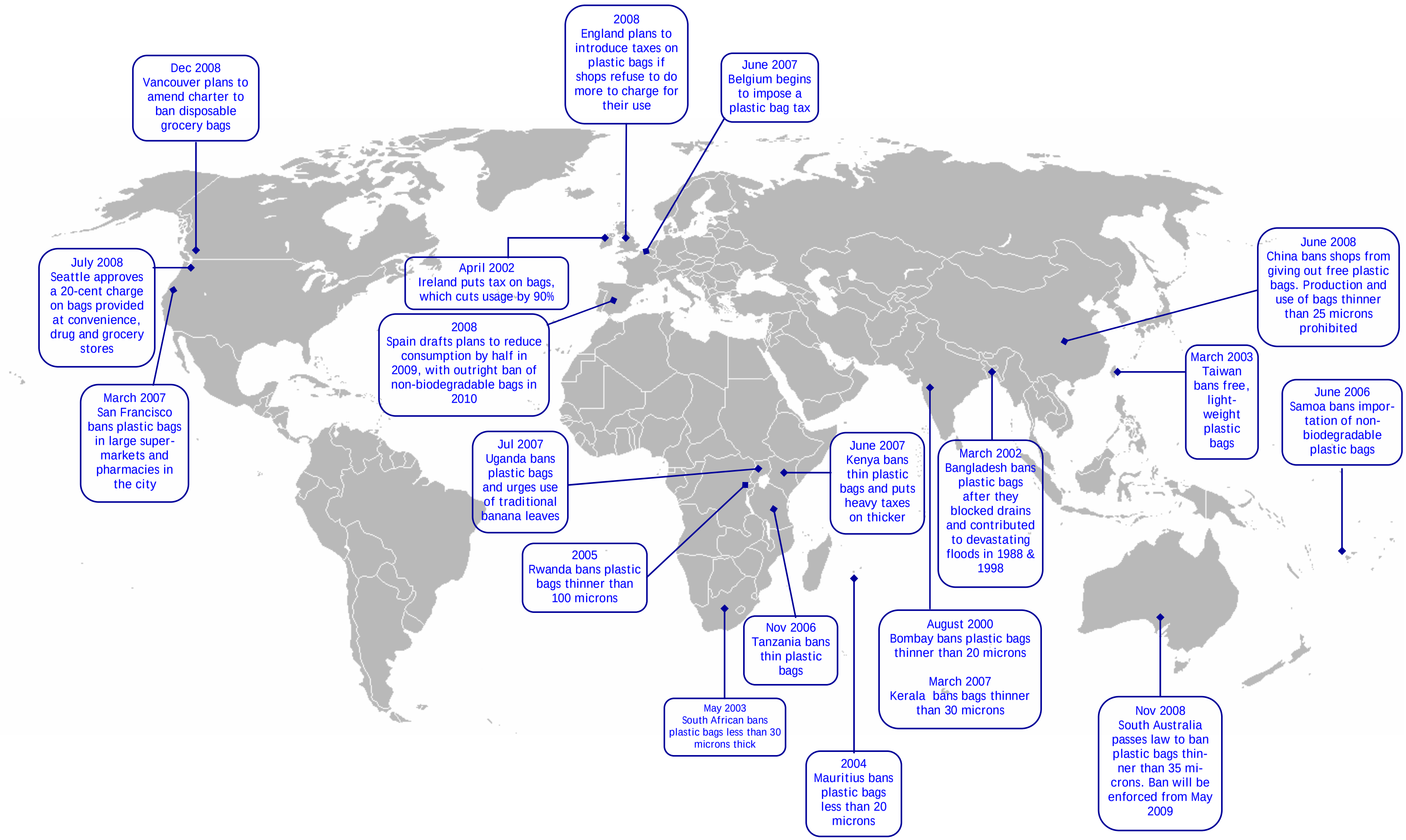
The following table provides contact details for suppliers of plastic bags which have been certified by one or more of the certification systems given in Table 2. This list is not exhaustive and more suppliers for other products such as packaging, resin (raw material), etc., can be found from the web links in Table 2.

TABLE B.1: Suppliers of certified biodegradable/compostable products

NAME	ADDRESS	CONTACT DETAILS	WEBSITE
BIOSTARCH Technology PTE Ltd	137 Ann Siang Road 069715 SINGAPORE	Tel: +65 63 25 16 24 Fax: +65 62 20 43 12	www.biostarch.com
GRACE BIOTECH Corp	N° 44-3, Polowen, Polotsun, Hukou Hsiang 303 Hsinchu County TAIWAN	Tel: +886 (0)3 598 64 96 Fax: +886 (0)3 598 64 91	www.grace-bio.com.tw/
MINIMA Technology Co., Ltd	55 Liouyang E. St Beitum Distrrict, 406 Taichung TAIWAN	Tel: +886 4 22 41 58 88 Fax: +886 4 22 42 01 68	www.minimatech.com.tw
PLANTIC Technologies Ltd	51 Burns Road 3018 Altona, Victoria AUSTRALIA	Tel: +61 3 9353 7901 Fax: +61 3 9353 7900	www.plantic.com.au/
BioBag Australasia Pty., Ltd	Level 2, 37 Bligh Street, 2000 NSW, Sydney, AUSTRALIA	Mr. Neil Thomson Tel: +612 8333 8257 Fax: +61 415 939 521	www.biobaganz.com neil@biobaganz.com
IGN Korea Co., Ltd.	3F 66, Tongui-Dong, Jongno-Gu, Seoul 110-040	Tel: +82 2 732 2900 Fax: +82 2 732 2206	Email: iglk@naver.com

APPENDIX C:

Plastic bag initiatives around the world



APPENDIX D: Sample strategy for the management of waste plastics

Vision

The vision of this strategy is to achieve a reduction in the amount of plastic wastes that are generated and to reduce the environmental impact of those plastic wastes.

Background

<This section should describe the specific problems (environment, economic, social, etc) that plastic bags pose in your country. It should also include usage statistics (i.e., the various types and amounts of plastic bags imported or manufactured in the country.>

Supporting Framework

<Describe the existing legal and institutional framework that would allow you to implement this strategy. For example:>

> "This strategy for managing plastic wastes is supported by a National Solid Waste Management Strategy which is endorsed by the Government, and which highlights the issue of plastic bags as a priority issue. National solid waste management legislation and regulations have also been enacted, which require the issuance of permits for the importation of plastic products. Marine pollution legislation are also enacted to govern the pollution of the marine environment from land-based sources of pollution." etc, etc…

Coverage

<This section describes the town/village/district/region covered by this strategy. The strategy can also be national one covering the entire country.>

Time Frame

<Outline the time frame for implementation of the strategy. For example:>

> "This strategy comes into effect once the Government pledges its support for the implementation of the strategy. It subsequently covers a 12-month time period."

Definitions

Plastic bags as defined in this strategy refer to disposable plastic bags manufactured from high density polyethylene (HDPE), and low-density polyethylene (LDPE). Such bags are often issued from supermarkets, department stores, food outlets, etc.

Degradable plastic refers to plastic which undergoes a significant change in chemical structure under specific environmental conditions resulting in a loss of some properties. Degradable plastics can be categorized as **bio-degradable** which means that the degradation is caused by micro-organism (bacteria, fungi, algae), or as **oxo-biodegradable**, where degradation is initiated first by the reaction of additives, which cause the plastic to disintegrate, and subsequently by the action of micro-organisms.

Compostable plastic refers to plastic that undergoes biological degradation during the composting process to yield CO_2, water, inorganic compounds, and biomass at a rate consistent with other compostable materials and leaves no visible, distinguishable or toxic residue

Guiding Principles

The following guiding principles are used as the foundation on which to build the actions that will transform the management of plastic bags and reduce their environmental impacts.

Waste Hierarchy

As far as possible, initiatives for the management of plastic bag wastes will be based on the waste hierarchy, which is a generic strategic tool for waste management. The hierarchy to be used is a 4R model which, in order of preference, consists of the following activities:

i. Reduce: implement activities to reduce the generation of plastic bags
ii. Reuse: endorse and support initiatives that encourage the reuse of plastic bags
iii. Recycle: develop programmes to encourage the collection and exportation of plastic bags for recycling
iv. Recover: develop programmes to encourage the collection, and incineration (or exportation for incineration) of plastic bags, with energy recovered from the incineration process

Polluter-Pay Principle

This principle simply states that those responsible for causing pollution should pay the cost for dealing with the pollution in order to maintain ecological health and diversity. Applied to plastic bags, it implies that those who generate plastic bag wastes should bear the cost for the collection and disposal of those wastes.

Extended Producer Responsibility

This is a strategy that makes companies, who are responsible for the manufacture, importation and/or selling of products and packaging, responsible for such products after their useful life. Their responsibility can be either financial (i.e, they pay the management costs for dealing with the wastes), or physical (i.e., they bear responsibility for taking back and managing waste products).

Sustainable Development Principle

Sustainable development requires that waste management be carried out in a way that does not place undue social, economic or environmental burdens on either present or future generations.

Precautionary Principle

Where there are threats of serious or irreversible damage, lack of scientific data and certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Proximity Principle

This principle states that waste should be dealt with as close to the source of generation as possible. This reduces transportation costs, and also reduces risks of contamination of the environment during transport.

Consultation Principle

Government at all levels will consult and work with people and organizations throughout the development and implementation of the waste management strategies and action plan.

Tools to reduce plastic bag usage and environmental impacts

<As described in this document, there are several tools that can be used to reduce the consumption of plastic bags, and consequently the environmental impacts. This section uses the information provided in this publication to compile a summary of suitable tools.>

Plastic bag ban

An outright ban on plastic bags is enforced through legislation which prohibits the importation and use of certain categories of plastic bags, such as plastic bags thinner than a certain value, or non-biodegradable plastic bags, or even all plastic bags. Banning plastic bags is a decision that must be taken after due consideration for the impacts on the country's manufacturing sector, and the environmental benefits to be derived from the ban.

As the case of Papua New Guinea (PNG) shows, an outright ban can backfire. In 2005, the PNG Government tried to ban the use of plastic bags, however, they were barred from doing so by a court ruling in favour of two major plastic bag manufacturers – Colorpak Ltd, and W.H. Industries Ltd. Colorpak Ltd reported that a ban on plastic bags would cause the closure of their business, job losses and said the proposed ban contravened investment laws and the constitution.

Compulsory plastic bag tax

A compulsory plastic bag tax is a form of economic instrument that is mandated by legislation and is applied to importers and producers of plastic bags, who subsequently pass on the tax to consumers. Legislation can specify that the tax should not be charged directly to consumers as a 'plastic bag tax', as opposed to indirectly where it is built into the cost of products being sold. The level of the tax could be set to recover the costs of collecting and disposing of plastic bags, and also to discourage plastic bag use. All the money generated from such a tax should go directly to a fund administered by the Waste Management Authority for use in waste management, enforcement and clean-up activities. If a tax is introduced, it is also important that alternatives be made available, such as reusable bags. Several countries utilize this method, such as Ireland, Italy, Belgium, Germany, and Switzerland.

Voluntary plastic bag tax

Usually, the cost of providing plastic bags to customers is included into the cost of the goods being sold. Consumers perceive that the bags were given to them for free, although they have paid indirectly. Imposing voluntary levies would involve supermarkets, stores, etc., exposing the true cost of the plastic bag to consumers, so that they pay directly for the quantity they use, and thereby become more aware of the cost.

As with compulsory plastic bag tax, an alternative must be provided so that the consumer can make an informed decision. Also, it is important that there is wide participation by the private sector in the voluntary scheme. For example, if only a few supermarkets or shops tax plastic bags, this might cause consumers to shop at competitors who have not imposed the tax, thereby creating an unfair disadvantage.

This voluntary scheme has been used on a trial-basis in Victoria, Australia with an average reduction of 79 percent in plastic bag consumption over a 4-week period.

Alternative bag trials

Alternatives such as reusable cotton bags, paper bags, and traditional solutions like the bilum bag of Papua New Guinea, and the coconut basket of Samoa and Fiji, provide consumers with practical alternatives that can help to discourage the use of thin plastic bags. Options which include degradable plastic bags, while they may not discourage the use of bags, offer a potential benefit of reducing the environmental impact of discarded bags.

Alternative bag trials involve offering alternative and reusable bags, such as calico or cotton bags, or degradable bags at reasonable and attractive prices. This approach has been used successfully in both Samoa and Kiribati for reusable bags.

Code of practice

A code of practice is a voluntary measure which sets out broad guidelines for signatories to follow. It is not legally binding and is self-regulated. Codes of practice are beneficial in that they do not require drafting and enacting of legislation, which can at times be a lengthy process. However, unless the signatories are genuinely committed and are self-motivated to adhere to the codes, the codes become effectively useless.

In the case of plastic bags, a code of practice would spell out, among other things: specific targets, and initiatives to promote reduction and recycling of plastic bags, campaigns to encourage use of alternative bags, and wider public education and awareness initiatives to be undertaken by signatories.

This approach is used in Australia, where the Code of Practice for Supermarket Carry Bags, and the National Packaging Convent are in place.

Collection for recycling

Collecting plastic bags for recycling is mostly done in developed countries where infrastructure exists for collection and recycling. For example, in Canada about half of the population has access to recycling through a combination of curbside programmes, drop-off depots or take-back programmes operated in some stores. Collected bags are then recycled into other consumer products such as plastic furniture, signage, etc. Collection for recycling will be more successful if undertaken along with other promotional activities to encourage participation, for example, the distribution of a reusable bag for returning a certain quantity of plastic bags.

In Samoa a joint initiative involving Corporate Recycling Pty Ltd (now Repeat Plastics Australia - Replas), and Australian Arrow Pty Ltd (formerly Yazaki Australia), and the Samoan Government, was undertaken in 2006. Under this initiative, Samoa ships its plastic waste to the Replas processing plant in Victoria, Australia where it is recycled and converted into sustainable products such as plastic furniture, signs, etc, to be exported back into Samoa.

Community awareness and education

Community awareness and education is an integral component of each tool discussed above. It is important that the general public understands the aims and objectives of different programs, so that they would be more willing to participate. Implementing changes without consultation and appropriate awareness/education is a recipe for disaster.

Degradable plastic bags

Degradable bags do not necessarily reduce the usage of plastic bags, however, they have the potential benefit of degrading more quickly, when carelessly discarded in the environment. Many types of degradable bags exist, characterized either by their composition or mode of degradation. Choosing the most appropriate type(s) of bag is a matter of economics, social acceptance, and the broader goals for national waste management.

Degradable plastic bag use can be mandated by law, as done by Samoa, where importation and use of non-biodegradable plastic bags is prohibited. Alternatively, their use can be encouraged through voluntary schemes as described above, where degradable bags are offered as an alternative to the conventional plastic bag.

Action Plan

The following plan of action suggests the activities to be taken to implement this strategy and thereby achieve progress on the management of plastic bags.

Activity	Date for implementation	Responsibility Agency or Person
Establish a cross-sectoral multi-stakeholder committee to take the issue of plastic bags forward. Develop and agree on terms of reference for committee, such as:		
• Gather background information, such as the usage of plastic bags in the country, the specific environmental effects and threats caused by improper disposal, the associated economic activities.		
• Create short-list of viable options for managing plastic bags based on the specific social, economic, political conditions of the country		
• Consult with key stakeholders to agree on an approach to the management of plastic bags		
• Determine institutional, legislative, and economic implications of agreed approach, and determine the budget and timelines.		
• Develop budgeted proposal based on consultation outcomes to present to cabinet for approval		

APPENDIX E:

SPREP PLASTIC BAG FACTSHEET

SPREP

Factsheet

Plastic Bags

Costs of plastic bags

More than a billion single-use plastic bags are given out freely each day. But while they may be free at the shops, they are costing our earth in many ways.

Phase 1: Production costs

- The production of plastic bags requires petroleum and often natural gas, both non-renewable resources that increase our dependency on foreign suppliers. Additionally, prospecting and drilling for these resources contributes to the destruction of fragile habitats and ecosystems around the world.
- The toxic chemical ingredients needed to make plastic produces pollution during the manufacturing process.
- The energy needed to manufacture and transport disposable bags eats up more resources and creates global warming emissions.

Phase 2: Consumption costs

Annual cost to US retailers alone is estimated at $4 billion. When retailers give away free bags, their costs are passed on to consumers in the form of higher prices.

Phase 3: Disposal and litter costs

Hundreds of thousands of sea turtles, whales and other marine mammals die every year from eating discarded plastic bags mistaken for food. Turtles think the bags are jellyfish, their primary food source. Once swallowed, plastic bags choke animals or block their intestines, leading to an agonizing death. On land, many cows, goats and other

Those plastic bags in our landfills will be present for up to 1,000 years.

It seems as though every time we go to a shop we are given a plastic bag...

that we usually throw away! And when these bags end up in the ocean...

they can harm wildlife, like turtles, who think they are food.

The next time you go shopping, take a cloth bag or basket to the shops, and say "no" to plastic.

animals suffer a similar fate to marine life when they accidentally ingest plastic bags while foraging for food.

In a landfill, or in the environment, plastic bags take up to 1,000 years to degrade. As litter, they eventually break apart into tiny bits, contaminating our soil and water. The resulting small plastic particles can pose threats to marine life and contaminate the food web. Researchers have found that plastic debris acts like a sponge for toxic chemicals, soaking up a million fold greater concentration of such deadly compounds as PCBs and DDE (a breakdown product of the notorious insecticide DDT), than the surrounding seawater. These turn into toxic gut bombs for marine animals which frequently mistake these bits for food.

Collection, hauling and disposal of plastic bag waste create an additional environmental impact. All plastic bags that are produced and imported into our islands inevitably end up as solid waste, putting an unnecessary burden on our diminishing landfill space and causing air pollution if incinerated.

Recycling requires energy for the collection, processing, etc. and doesn't address the above issues.

Plastic bags thrown in the streets as litter block drains and can lead to flooding during heavy rains, and consequently to property damage. Bags can also act as water traps, with the stagnant water a breeding ground for the mosquitoes that spread diseases like dengue fever.

What about biodegradable bags?

Biodegradable shopping bags are made of polymers that degrade, or decompose, when exposed to air, water or sunlight. There are two main types:

1) The original biodegradable bags, introduced more than ten years ago, are made from resins containing polyethylene, starches and heavy metals such as cadmium, lead, and beryllium. They are still on the market today.

2) About eight years ago, a second type was invented using starches combined with biodegradable polymers such as polylactic acid. Some of these claim to be fully compostable, meaning that they would break down to organic material suitable for plant growth.

Biodegradable bags may seem like a good idea, but they too are not without environmental cost. The breakdown of starch-based plastic in water consumes oxygen, resulting in oxygen depletion that contributes to algae blooms and the death of marine life. Further, littering could increase as people start to believe that biodegradable bags are less harmful to the environment and will disappear quickly (it takes at least 18 months for most to breakdown).

The jury is still out. Debate continues on whether or not biodegradable plastic bags consume a similar amount of energy during their life as regular non-biodegradable bags. Despite these drawbacks, it is clear that, unlike traditional plastic bags, biodegradable bags break down in landfills and thus ease the burden on diminishing landfill space.

What can you do?

- Take your own bags to the supermarket – when you leave the house remember your keys, wallet and bags.
- Say "no" to excess wrapping and packaging.

What is SPREP doing?

SPREP publishes guidelines for policy makers on measures that can be used to discourage the use of plastic bags, and encourage the use of more sustainable alternatives.

In the past, SPREP has sponsored a "bring your own bag" campaign that highlighted the dangers of plastic bags and provided reusable cloth alternatives to shoppers.

Plastic Bag Facts

- Plastic bags were first introduced 25 years ago.
- Worldwide, more than 500 billion plastic bags are used each year (nearly 1 million bags per minute).
- Plastic bags cause over 100,000 sea turtle and other marine animal deaths every year when animals mistake them for food.
- It is believed that 90% of all rubbish floating in the ocean is made up of plastic.
- Scientists estimate that every square mile of ocean contains about 46,000 pieces of floating plastic.
- A vast area of floating rubbish, "The Plastic Soup," was recently discovered in the northern Pacific.
- 80% of the plastic bags floating in the ocean originated from open dumps and not from ships.
- The amount of petroleum used to make a plastic bag would drive a car about 115 metres. It would take only 14 plastic bags to drive one mile!
- Some 66 million plastic bags are used annually in Fiji (that's 83 bags per person).
- Australians consume about 6.9 billion plastic bags annually, or about 326 per person; an estimated 49.6 million bags end up as litter each year.
- The U.S. uses 100 billion plastic shopping bags annually. An estimated 12 million barrels of oil is required to make that many plastic bags.
- 80% of grocery bags in the US are now plastic.
- Taiwan has banned both plastic bags and plastic utensils.
- Only 1 in 200 plastic bags in the UK are recycled.
- In 2006, the Government of Samoa banned the importation of non-biodegradable plastic bags.

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