HEALTH + SUSTAINABILITY

liverpool JMU Centre for Public Health

FACT SHEET 5:

SUSTAINABLE PLASTIC USAGE AND PUBLIC HEALTH

SEPTEMBER 2009

KEY POINTS

- plastic is a generic term that refers to about 50 different families and hundreds of varieties of materials, made from hydrocarbon molecules derived from coal, gas and oil
- plastics are among the most common materials produced today. They are lightwieght, durable, resistant, hygienic, thermal and electrical insulating, and economical
- the world's annual consumption of plastic in 2006 was about 100 million tonnes, with applications in almost every sector, with the UK accounting for more than 4.7 million tonnes
- the packaging industry is the largest single UK consumer of plastic, followed by building and construction, and transport
- in the medical sector, plastic is essential for the production of disposable, flexible, easily sterilised equipment and containers
- most of the health and eco-benefits of plastic relate to:
  - the limited use of natural resources and the relatively low levels of greenhouse gases emitted during their production, especially when compared to other materials that might serve a similar function
  - the relatively low amount of fuel used and carbon emitted during transportation
  - the improved energy efficiency provided when used for home insulation
  - the possibility of material recycling and energy recovery when disposed as waste
- however, there are significant environmental issues, mainly relating to plastic litter and the slow breakdown of plastics. There are also significant health concerns focusing on noxious plastic additives, such as colourants, flame retardants and plasticisers, which can leach from plastic products. These are of particular concern in products such as medical equipment and feeding bottles for infants.

INTRODUCTION

Plastic is a generic term that refers to about 50 different families and hundreds of varieties of materials [1]. The word derives from the Greek "plastikos", meaning 'able to be moulded', and refers to the material's malleability during manufacture, which allows moulding into almost limitless different shapes [2].

Plastics are polymers; complex chains of simple hydrocarbon molecules (monomers) derived from coal, gas and oil. Polymer production takes place in large vessels through the use of catalysts[1] and under particular temperature and pressure conditions. The end result can be in the form of a liquid, resin pellet or powder. These are then heated until they are soft enough to be moulded into the required shape, mainly by extrusion or injection [1,3,4]. Solid articles are produced by injecting heated plastic at high pressure into a mould; whereas, extrusion refers to the process of producing long elements, such as cables, by mechanically pushing heated plastic into a die. If pressurised air or gas is forced into the mould or through the die, hollow articles, like bottles, can be produced. When cooled, the plastic retains the shape it was moulded into. Some additives, such as colourants, flame retardants and plasticisers, can be added to the polymers to improve their appearance or performance [4-6].

BOX 1: PLASTICISERS

Plasticisers are substances that are added to the polymers to make plastic flexible and soft, even at room temperature.

It is not exactly certain how plasticisers work. One theory is that they embed themselves between the chains of polymers, increasing the internal space available for movement. Another theory suggests that plasticisers 'lubricate' the polymer chains by reducing intermolecular friction [7,8]. There are approximately 300 different types of plasticisers, the majority of which are man-made. They are mainly colourless and odourless substances [9]. However, some plasticisers evaporate readily and produce the classic 'plastic-like' odour, often referred to as a 'new car smell' [8].

The most common plasticisers are probably phthalates. This is a family of acids widely used to soften polyvinyl chloride (PVC). Soft PVC products include toys, floor tiles, shower curtains, vinyl upholstery, food containers and wrappers. However, phthalates are also used in adhesives and glues, building materials, lubricants, paints and inks, pharmaceuticals, food products, textiles and personal care items, such as perfumes, moisturisers, nail polish, liquid soap and hair spray [7-10].

[1] Catalysts are compounds that speed up reactions without getting consumed.

BOX 2: THE MOST COMMON THERMOPLASTICS AND THERMOSETS

Most common thermoplastics	Examples of use
high density polyethylene (HDPE)	bottles for detergents; food products; milk bottles; toys; shopping bags
low density polyethylene (LDPE)	cling-film; bin liners; flexible containers
polyethylene terephthalate (PET)	water bottles; fizzy drinks bottles; food packaging
polypropylene (PP)	yogurt and margarine pots; automotive parts; fibres; milk crates
poly vinyl chloride (PVC)	window and door frames; flooring; wallpaper; bottles; medical products; fashion and footwear
polystyrene (PS)	toys; rigid packaging; refrigerator trays and boxes; cosmetic packs; lighting diffusers; audio cassette and CD cases
polycarbonate (PC)	rigid bottles and baby bottles; bullet-proof glass; eyewear lenses; lab equipment

Most common thermosets	Examples of use
polyurethane (PUR)	coatings; finishes; mattresses; vehicle seating; building insulation
epoxies (EP)	adhesives; boats; sporting equipment; electrical components; automotive components
phenolics (PF)	ovens; circuit boards
unsaturated polyesters (UP)	wind turbines; car body parts; boats; aeroplanes; trucks and buses; fishing rods; work surfaces

[Adapted from 1 and 11]

There are two basic types of plastics: thermoplastics and thermosets. The first soften when heated and harden on cooling, and can be re-melted and re-moulded several times. The second are hardened by a curing process so that, once moulded in the final shape, they cannot be re-melted or re-moulded. More than 80% of plastics worldwide are thermoplastics [1,3,11]. Examples of thermoplastics and thermosets are shown in Box 2.

In the last 50 years, plastics have become very popular [12-14]. Mainly because of their:

- versatility to meet very specific technical needs
- lightweight
- durability
- resistance to chemicals, water and impact
- good safety and hygiene properties
- thermal and electrical insulation properties
- relatively low cost

The world's annual consumption of plastic materials has increased from around 5 million tonnes in the 1950s to about 100 million in 2006, with applications in almost every sector of life and industry. Western Europe consumes more than 33.5 million tonnes of plastic annually, with the UK accounting for more than 4.7 million tonnes [1,14-16].

The packaging industry is the largest single consumer of plastic, and according to the plastics trade association accounts for 40% of total plastic consumption in Europe, 35% in the UK. In total, about 50% of all goods are packaged in plastic wrapping, usually polyethylene film, used mainly because of its low weight and relative strength [1,14-17].

The second largest user in the UK is the building and construction sector, accounting for 22% of total plastic consumption. Plastic is widely found in pipes and ducts, insulation and windows and floor coverings.

PVC accounts for 60% of the plastic used in this sector [1,6,14]. PVC, along with polyethylene, is also used as cable insulation in the electrical and electronic sector, and accounts for 6% of the total plastic consumption in the UK [1,14-16].

Data for 2001 [14-16] indicate that other UK sectors that use high levels of plastics are[2]:

- transportation (including automotive) – 8%
- furniture/houseware – 8%
- agriculture – 7%
- toys and sport – 3%
- mechanical engineering – 2%
- medical – 2%
- footwear – 1%
- other uses (e.g. stationery and gardening) – 3%

In the medical sector, plastics are essential as they allow the production of lightweight, resistant, flexible, hygienic equipment that can be easily sterilised such as: blood and plasma bags, surgical gloves, heart and lung bypass sets, blood transfusion sets, blood vessels in artificial kidneys, catheters, syringes; as well as blister packs for drugs [15,16,18].

Plastics facilitate the production of lightweight and hard safety equipment such as crash helmets and airbags [19,20].

SUSTAINABILITY AND HEALTH

Most of the health and eco-benefits of plastics relate to the limited use of natural resources and the relatively low levels of greenhouse gases (GHGs) emitted during their production, use and disposal, compared to other materials that might serve a similar function.

GHGs contribute to climate change with its detrimental health effects both nationally and internationally [21,22]. It is anticipated that the greatest effects will be felt by the poorest communities, who have the least access to the world's resources, and this will serve to increase health inequity [22].

Only 4% of the world's oil is used to produce plastics and it takes far less energy to make things out of plastic, than it would to make the same thing from other materials [1,23,24].

Without plastic packaging, and based on the current situation, it has been estimated that the tonnage of alternative packaging materials would increase by a factor of 4; emissions of greenhouse gases by a factor of 2; costs by a factor of 1.9; energy use by a factor of 1.5; and waste by a factor of 1.6 in volume [23,25-27].

Use of lightweight plastic in transportation has clear beneficial effects. According to the British Plastic Federation [24], the average new car in 1984 contained 8.5% plastics by weight. A similar car today contains around 11%, reducing the weight of the vehicle, fuel consumption and consequently emissions. Similarly, the European Plastics Federation highlights that a new aircraft today contains about 25% more plastic in weight than 30 years ago [28].

In the construction sector, the production of plastic pipes uses less energy and emits less green house gasses than concrete or iron, and due to their light weight they save on transport costs [24]. Furthermore, plastics, such as EPS foam, are used for home insulation, contributing to the energy efficiency of the building and to the health and wellbeing of the occupants. It has been estimated that 1kg of oil used to make EPS will save the equivalent of 75 kg of oil for heating over 25 years of a building's lifetime [24]. Appropriate use of plastics can reduce the lifetime output of CO_2 from a building by between 70% to 75% [1,29].

Plastics also contribute to renewable energy production. Unsaturated polyesters and polycarbonates enable the construction of more efficient rotors in wind turbines and effective solar and photovoltaic panels which in turn helps to preserve non renewable resources such as oil and coal and reduce carbon emissions [30,31].

[2] According to the British Plastics Federation, some of these figures have changed around +/-1%, in 2006 [16].

Plastic waste can contribute significantly to resource and energy recovery. It has been estimated that recycling plastic bags can:

- save about two-thirds of the energy needed to manufacture new bags
- save 90% of the water used in the manufacture of new bags
- reduce carbon emissions by approximately two-and-a-half times compared to new bags [13,26]

Much plastic waste can easily be recycled by melting and moulding it into new shapes (mechanical recycling), or even by breaking it down into the basic raw materials (feedstock recycling). These can be re-used as primary feedstock in a new plastic production line, or as secondary feedstock in refineries, petrochemical and chemical reactors [1,24]. Some plastic packaging, such as carrier bags can be reused several times, saving resources and energy, and helping to reduce CO_2 emissions [23,32]. Plastic waste has a high energy content (or 'calorific value') which can be recovered in an energy-from-waste incinerator [1,24].

ENVIRONMENTAL AND HEALTH CONCERNS

The production of plastic has a range of environmental and health impacts, in particular:

- the total quantity of oil used in the production of plastic is actually about 8% of the world's oil output, if the fossil fuel used in the process is included in the calculation [26]
- carbon dioxide and methane are emitted during plastic production. These greenhouse gases contribute to climate change [33] and increase the associated risks to human health [21,22]
- it has been estimated that the production of 5 plastic bags, or 2 plastic bottles, adds 1 kg of CO_2 to a personal carbon footprint. This calculation takes into account a wide range of impacting factors such as transportation of raw material and the use of land [34]
- many noxious chemicals are used in plastic production, some of which can be emitted into the atmosphere. Additives such as colourants, plasticisers (phthalates, in particular) and flame retardants have been linked to possible reproductive effects in the female workforce [35]. Volatile Organic Compounds (VOCs), such as styrene, used in the production of reinforced plastics, are important air toxins which can increase chronic health problems in exposed populations and may have potential effects on the reproductive system [36,37]. Studies have also reported occupational asthma in workers in the rubber and plastic sector, in particular in relation to polyethylene production [38,39]

Plastic additives, such as plasticisers and flame retardants are also of concern as they can leach from plastic furniture, vinyl flooring and PVC windows/doors; or migrate from the packaging to the food or liquid they are covering; or even be directly ingested, mainly by children, as debris and dust released from toys and furniture [40].

Bisphenol A (BPA) and phthalates are common plasticisers which have been detected in breast milk, urine, semen and follicular fluid, placental tissue and amniotic fluid, and blood [40,41].

The primary route of exposure appears to be ingestion of solid and liquid food contaminated by wrapping films and plastic containers, including polycarbonate baby bottles. Some studies have found that these chemicals can significantly leach from polycarbonate bottles if they are heated to high temperature (e.g. 100°C), and if they contain fatty food (e.g. oil or milk) [40,42,43]. Prenatal exposure has also been verified, possibly through ingestion of contaminated amniotic fluid [40,41,44-49]. For newborns, an unusual phthalates exposure pathway appears to be via PVC medical equipment such as catheters, nasogastric and transfusion tubes, nutrition storage and blood bags [41,42,45,50,51].

Many studies have linked BPA and phthalates to endocrine disruption and reproductive system problems [40-42,45,48,49,52]. Although it does not appear to be carcinogenic on its own, BPA appears to increase susceptibility to certain cancers, such as prostate and mammary cancers; to induce inflammation or allergic responses [41,48,49]; and has been correlated with increased risk of cardiovascular diseases and diabetes [53].

The release of phthalates by PVC into indoor air has been clearly linked to an increased risk of asthma in children [41,54].

Babies and toddlers appear to be particularly at risk because:

- their exposure to these products exceeds that of an adult as they eat and drink proportionately more (for their volume) and have less variety in their diet, during development
- developing tissues are very sensitive to endocrine signals and disruption [40-45,50-52,54,55]

The European Union has already set limits on their uses, in particular, in relation to children [47,56]. However, the majority of toxicity studies are based on laboratory experiments on mice; and human exposure is often only estimated [40,42,45,48,49, 54]. Studies on humans are limited and they mainly establish inconclusive correlations between exposure and outcome; are based on studies with a small sample size and with a lack of control of possible confounding factors [40,57]. Furthermore, these products are ubiquitous in our environment and, therefore, studies on single exposures are very difficult [41,42,45,52]. Many human health risk assessments have been carried out [42,56] and others are underway [58-61].

Plastic waste is also a matter of serious concern. Even though plastic waste in Europe accounts for less than 1% of the total waste produced every year [1], the amount of plastic waste generated annually in the UK is estimated to be nearly 3 million tonnes. About 56% of all plastic waste comes from packaging, three-quarters of which is from households [14,26]. On average, 40% of plastics have a useful lifetime of less than one month [62]. Only 7% of total plastic waste is currently recycled [14,26]. Plastic recycling plants in UK are limited [14,63] and, in order to meet the recycling targets set by the EU Directive on Packaging and Packaging Waste, the majority of plastic waste is sent abroad, increasing the total cost of the disposal process and its carbon footprint [64-66].

BOX 3: TYPES OF PLASTICS RECYCLED IN THE UK

Recycling symbol	Polymer type	Potential for recycling
1 PET	polyethylene terepthalate	widely recycled in the UK
2 HDPE	high density polyethylene	widely recycled in the UK
3 PVC	polyvinyl chloride	partially recycled in the UK
4 LDPE	low density polyethylene	not generally recycled in the UK
5 PP	polypropylene	not generally recycled in the UK
6 PS	polystyrene	not generally recycled in the UK
07-19 PET	all other polymers	not generally recycled in the UK

[Adapted from 67]

Currently, 8% of plastic waste is incinerated [14]. Most related health concerns focus on possible uncontrolled air emissions of poly aromatic hydrocarbons (PAH), dioxins and furans from the incineration of PVC. Fly ash and bottom ash (residues from incineration) can also contain dioxins/furans and PAH that, when handled or disposed of in landfills, can be dispersed into the environment and ultimately pass up the food chain to human consumers [68-73]. These noxious compounds can have many adverse effects in humans. In particular, they are known to be carcinogenic, mutagenic and immunotoxic [70-73].

The remaining 85% of plastic waste is mainly disposed of in landfills, with a small portion dispersed into the environment. However, commonly used polymers have poor biodegradability [62] and most plastics persist in our landfills and in the environment for years. For example, plastic films last 20-30 years while plastic bottles can last indefinitely [33]. When dispersed in the environment, plastic breaks down gradually through mechanical action into microscopic plastic pieces known as plastic dust, which eventually spread everywhere and can easily be ingested by animals [74].

The marine setting is at particular risk, since in this environment, plastics, even bioplastics, break down more slowly than on land owing to lower average sea temperatures [33,75]. Estimates for plastic degradation at sea range from 450 to 1,000 years [74]. There are about 46,000 pieces of plastic floating in each square mile of our oceans [33].

Plastic 'dust' can be ingested by filter feeding marine animals; while bigger debris and plastic bags can be mistaken for food and consumed by a wide range of other marine species [74]. Some chemical additives in the plastic, such as bisphenol A, are toxic [75] and can bioaccumulate in fish. The plastic surface of large debris accumulates pollutants such as noxious organic compounds and heavy metals at concentrations much higher than in ocean water [74,75]. Toxins can then be passed up the food chain to human consumers [74]. However, the pollution of the marine environment can have other more complex effects, such as an increase in waterborne pathogens and exuberant growth of noxious algae [76].

Plastic litter causes severe entanglement of marine animals [33,74,76]. It is estimated that plastic kills up to one million sea birds, 100,000 sea mammals and countless fish each year, with many getting entangled in six-pack rings, plastic bags, plastic strapping and nylon ropes [33].

Plastic carrier bags do not represent a significant proportion of our waste but they are a symbol of our wasteful society, mainly because they are often disposed of irresponsibly [23,77].

According to the Friends of the Earth [78], approximately one million plastic bags are used worldwide every minute. In England, 9.9 billion new carrier bags were given away in 2008, an average of 400 bags per household [77,79]. The majority of bags are then disposed of in landfills or incinerated, and only one in every 200 bags is recycled [80]. The wind blows plastic bag litter from landfills, and the majority ends up in the sea [78]. In UK, on average 43.2 bags were found for every kilometre of coastline surveyed by the Marine Conservation Society in 2003 [74]. In total 5,831 plastic bags were found on the 244 beaches surveyed.

Some countries, such as Ireland, Italy, Belgium and the Australian state of Victoria, have implemented a fee per plastic bag, to discourage their use and recover hidden environmental costs. Many other nations are considering a ban [81]. China has already banned the use of plastic bags since 1 June 2008, mainly to reduce oil consumption [82]. In March 2002, Bangladesh banned polythene bags on the grounds that they contributed significantly to two major floods between 1988 and 1998 by blocking drainage systems [83]. Nevertheless, evidence on the effectiveness of these extreme measures is controversial [84-86].

The UK Government is taking action to support the re-use of plastic bags, the reduction of plastic packaging in the waste stream and the recycling of plastics more generally [77]. The reduction target of 50% for single-use plastic bags set with the British Retail Consortium on a voluntary basis was very nearly met [77]. In total, 870m single-use plastic bags were handed out in the UK in May 2006, and the figure for May 2009 was down to 450m – a 48% reduction, with 4,740 tonnes to send to landfill

BOX 4: BIOPLASTIC BAGS

Alternatives to polyethylene plastic bags are now in place and include 'biodegradable' plastics and paper bags. The use of paper bags is not welcomed by all, since their use may lead to a bigger carbon footprint [88].

Plastic is not naturally biodegradable and its molecular structure needs to be modified through the introduction of an additive, which will then allow it to degrade. Additive-based polyethylene bags degrade if exposed to light (photodegradable) and/or oxygen and high temperatures (around 60°C), depending on the additive used. In an open landfill, it can take between 6 and 24 months to degrade. However, if the landfill is sealed, the process can continue for several years and it is not known whether it completely degrades or not. The risk of partial degradation means that these bags cannot be used for composting as they may pollute the compost [89].

Starch plastic (known as compostable plastic) is not a true plastic. Corn, potatoes or wheat is used to make a biodegradable film, which has similar properties to polyethylene. It is completely degradable and compostable (in industrial facilities only) but it is not as durable and robust as polyethylene. Furthermore, in a sealed landfill, the degradation process may take several months; and, if mixed with other plastics, the value of recycling is reduced [89].

against 8,890 tonnes in May 2006. Under the Climate Change Act, The Government is ready to impose a charge on single-use carrier bags if insufficient progress is made [87].

CONCLUSIONS

Plastics are a fundamental part of modern life and have both positive and negative features in relation to sustainability, the environment and health.

They are widely used in almost every industrial sector, and can contribute to sustainable development. [15,16,18]. Because of its lightweight and relative strength, plastic packaging can reduce fuel consumption and carbon emissions relating to the transportation of goods. Plastics used for home insulation can contribute significantly to the energy efficiency of the building, thereby improving the health and wellbeing of the occupants.

Nevertheless, there are several problems relating to the production and post-use disposal of plastics. Most plastics are made from oil, which is a non-renewable resource. Some plastic packaging appears to have a very short useful life. Insufficient plastic is reused or recycled and much is still disposed of in landfills where it can persist for many years. If dispersed in the environment, it can endanger animals and jeopardise biodiversity, interfering with natural controls on the spread of diseases [90,91]. Incineration of plastic, despite providing an alternative source of energy, raises concerns about the emission of potentially noxious chemicals such as dioxins, furans and PAH, in the flue gases, bottom and fly ash, and in the effluent of pollution control devices.

Most health concerns focus on the noxious plastic additives, such as colourants, flame retardants and plasticisers, which can leach from plastic furniture, vinyl flooring, PVC windows/doors, plastic toys and food packaging, including polycarbonate baby bottles. Young children and toddlers appear to be particularly at risk because for their size, they eat and drink more than adults and have less variety in their diets. Their tissues are very sensitive during development, and they can more easily accidentally ingest plastic debris.

BOX 5: AREAS FOR RESEARCH AND DEVELOPMENT

Possible areas for research and development could include:

1) evaluation of the overall sustainability and health benefits that plastics can bring, considering also their contribution to lowering carbon emissions. These positive impacts have not yet been fully quantified

2) further and wider studies on plastic additives and their potential for harm to human health, possibly by undertaking a study with a sufficiently large sample size and using an appropriate methodology to control for confounders. Particular attention should be paid to children

3) economic evaluation of the health risks potentially posed by PVC medical equipment and weighing these up against the benefits

4) exploration of possible alternative additives that are less toxic or encouraging the use of non-plastic materials, where appropriate

REFERENCES

1. Warmer Bulletin Information Sheet. Plastic. Skipton; 2003. Available at: http://www.residua.com/Residua/Warmer_Bulletin.html [Accessed 24 April 2009]
2. Online Etymology Dictionary. Plastic [online]. 2003. Available at: http://www.etymonline.com/index.php?search=plastic&searchmode=none [Accessed 3 July 2009]
3. PlasticsEurope. How plastic is made [online]. N.D. Available at: http://www.plasticsEurope.org/Content/Default.asp?PageID=1063 [Accessed 3 July 2009]
4. ZeroWaste. Plastic. Zero Waste Fact Sheet. Perth; 2002. Available at: http://www.zerowastewa.com.au/documents/plastic_fs.pdf [Accessed 24 April 2009]
5. PlasticsEurope. Glossary [online]. 2009. Available at: http://www.plasticseurope.org/Content/Default.asp?PageID=1067 [Accessed 3 July 2009]
6. British Plastics Federation. Plastic Processes [online]. 2009. Available at: http://www.bpf.co.uk/Plastipedia/Processes/Default.aspx [Accessed 3 July 2009]
7. Plasticisers Information Centre. An overview of the plasticisation process [online]. 2009. Available at: http://www.plasticisers.org/index.asp?page=35 [Accessed 3 July 2009]
8. Wikipedia. Plasticizer [online]. 2009. Available at: http://en.wikipedia.org/wiki/Plasticizer [Accessed 3 July 2009]
9. Plasticisers Information Centre. Phthalates [online]. 2009. Available at: http://www.plasticisers.org/index.asp?page=10 [Accessed 3 July 2009]
10. Wikipedia. Phthalate [online]. 2009. Available at: http://en.wikipedia.org/wiki/Phthalate [Accessed 3 July 2009]
11. British Plastics Federation. Raw Materials - Polymers [online]. British Plastics Federation; N.D. Available at: http://www.bpf.co.uk/Plastipedia/Polymers/Default.aspx [Accessed 17 July 2009]
12. PlasticsEurope. Plastics applications [online]. 2009. Available at: http://www.plasticseurope.org/Content/Default.asp?PageID=1065 [Accessed 3 July 2009]
13. Mid Sussex District Council. Plastic information sheet. Oaklands: Midsussex District Council; N.D. Available at: http://www.midsussex.gov.uk/page.cfm?pageID=6149 [Accessed 24 April 2009]
14. Waste Online. Plastics recycling information sheet [online]. 2006. Available at: http://www.wasteonline.org.uk/resources/InformationSheets/Plastics.htm#_Types_of_plastic [Accessed 30 April 2009]
15. PlasticsEurope. The compelling facts about plastic. Brussels: PlasticEurope; 2008. Available at: http://www.plasticseurope.org/Content/Default.asp?PageID=989 [Accessed 15 May 2009]
16. British Plastics Federation. About the industry [online]. N.D. Available at: http://www.bpf.co.uk/Industry/Default.aspx [Accessed 3 July 2009]
17. Wasteonline. Packaging recycling information sheet [online]. 2006. Available at: http://www.wasteonline.org.uk/resources/InformationSheets/Packaging.htm [Accessed 3 July 2009]
18. PlasticsEurope. Healthcare. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/Content/Default.asp?PageID=988 [Accessed 3 July 2009]
19. PlasticsEurope. Protection. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/Content/Default.asp?PageID=988 [Accessed 15 May 2009]

20. PlasticsEurope. Stay safe with plastic. Brussels: PlasticsEurope; 2007. Available at: http://www.plastics europe.org/Content/Default.asp?PageID=988 [Accessed 3 July 2009]

21. Kovats S (ed). Health Effects of Climate Change in the UK 2008: An update of the Department of Health Report 2001/2002. London: Department of Health and Health Protection Agency; 2008.

22. Costello A, Abbas M, Allen A, et al. Managing the health effects of climate change. The Lancet; 2009;373:1693-1733.

23. PlasticsEurope. The compelling facts about plastic 2007. Brussels: PlasticEurope; 2008. Available at: http://www.plasticseurope.org/Content/Default.asp?PageID=989 [Accessed 15 May 2009]

24. British Plastics Federation. Plastic and Sustainability [online]. British Plastics Federation; 2008. Available at: http://www.bpf.co.uk/Plastics_and_Sustainability.aspx [Accessed 3 July 2009]

25. PlasticsEurope. Packaging. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/Content/Default .asp?PageID=988 [Accessed 3 July 2009]

26. Waste Online. Packaging recycling information sheet [online]. 2006. Available at: http://www.wasteonline.org.uk/ resources/InformationSheets/Packaging.htm [Accessed 3 July 2009]

27. PlasticsEurope. Packaging. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/Content/ Default.asp?PageID=999 [Accessed 3 July 2009]

28. PlasticsEurope. Mobility - how to make travelling easier on the environment. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/Content/Default.asp?Page ID=974 [Accessed 3 July 2009]

29. PlasticsEurope. Construction and Housing - perfect climate protection for houses and apartments. Brussels: PlasticsEurope; 2007. Available at: http://www.plastics europe.org/Content/Default.asp?PageID=991 [Accessed 3 July 2009]

30. PlasticsEurope. Climate protection. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/content/ Default.asp?PageID=988 [Accessed 3 July 2009]

31. PlasticsEurope. Renowable Energy - the power of the elements. Brussels: PlasticsEurope; 2007. Available at: http://www.plasticseurope.org/content/Default.asp?PageID=991 [Accessed 3 July 2007.

32. Ross S, Evans D. The environmental effect of reusing and recycling plastic-based packaging system. Journal of Cleaner Production; 2003;11:561-71.

33. UNEP. Ecosystems and Biodiversity in Deep Waters and High Seas. UNEP Regional Seas Report and Studies No. 178. Geneva: UNEP/IUCN; 2006. Available at: http://www.unep.org/pdf/EcosystemBiodiversity_DeepWaters_20060616.pdf [Accessed 7 September 2009]

34. Time for Change. What is a carbon footprint - definition [online]. Time for Change; N.D. Available at: http://timeforchange.org/what-is-a-carbon-footprint-definition [Accessed 3 July 2009]

35. Hougaard KS, Hannerz H, Feveile H, Bonde JP. Increased incidence of infertility treatment among women working in the plastics industry. Reproductive Toxicology; 2009;27:186-9.

36. Naccari A, Zanello A, Landi S, Consigli R, Migliore L. Sperm-FISH analysis and human monitoring: a study on workers occupationally exposed to styrene. Mutation Research; 2003;537:131-40.

37. Nylander-French LA, Kupper LL, Rappaport SM. An Investigation of Factors Contributing to Styrene and Styrene-7,8-oxide Exposures in the Reinforced-Plastics Industry. Annals of Occupational Hygiene 1999;43(2):99-109.

38. Jaakkola JJK, Piipari R, Jaakkola MS. Occupation and Asthma: A Population-based Incident Case-Control Study. American Journal of Epidemiology; 2003;158(10):981-7.

39. Gannon PFG, Burge SP, Benfield GFA. Occupational asthma due to polyethylene shrink wrapping (paper wrapper's asthma). Thorax; 1992;47:759.

40. Vanderberg LN, Hauser R, Marcus M, Olea N, Welshons WV. Human exposure to bisphenol A (BPA). Reproductive Toxicology; 2007;24:139-77.

41. Rudel RA, Petovich LJ. Endocrine disrupting chemicals in indoor and outdoor air. Atmospheric Environment; 2009;43:170-81.

42. Heudorf U, Mersh-Shustermann V, Angerer J. Phthalates: Toxicology and exposure. International Journal of Hygiene and Environmental Health; 2007;210:623-34.

43. Le HH, Carlson EM, Chua JP, Belcher SM. Bisphenol A is released from polycarbonate drinking bottles and mimics the neurotoxic actions of estrogen in developing cerebellar neurons. Toxicology Letters; 2008;176:149-56.

44. Huang P-C, Kuo P-L, Chou Y-Y, Lin S-J, Lee C-C. Association between prenatal exposure to phthalates and the health of newborns. Environment International; 2009;35:1420.

45. Matsumoto M, Hirata-Koizumi M, Ema M. Potential adverse effects of phthalic acid esters on human health: A review of recent studies on reproduction. Regulatory Toxicology and Pharmacology; 2008;50:37-49.

46. Sathyanarayana S, Calafat AM, Liu F, Swan SH. Maternal and infant urinary phthalate metabolite concentrations: Are they related? Environmental Research; 2008;108:413-8.

47. Ye X, Pierik FH, Hauser R, et al. Urinary metabolite concentrations of organophosphorous pesticides, bisphenol A, and phthalates among pregnant women in Rotterdam, the Netherlands: The Generation R study. Environmental Research; 2008;108:260-7.

48. Richter CA, Birnbaum LS, Farabollini F, et al. In vivo effects of bisphenol A in laboratory rodent studies. Regulatory Toxicology; 2007;24:199-224.

49. Wetherill YB, Akingbemi BT, Kanno J, et al. In vitro molecular mechanisms of bisphenol A action. Regulatory Toxicology; 2007;24:178-98.

50. Latini G. Monitoring phthalate exposure in humans. Clinica Chimica Acta; 2005;361:20-9.

51. Latini G, De Felice C, Verrotti A. Plasticizers, infant nutrition and reproductive health. Regulatory Toxicology; 2004;19:27-33.

52. Maffini MV, Rubini BS, Sonnenschein C, Soto AM. Endocrine disruptors and reproductive health: The case of bisphenol-A. Molecular and Cellular Endocrinology; 2006;254-255:179-86.

53. Lang IA, Galloway TS, Scarlett A, et al. Association of UrinaryBisphenolAConcentration With Medical Disorders and Laboratory Abnormalities in Adults. Journal of American Medical Association; 2008;300(11):1303-10.

54. Swan SH. Environmental phthalate exposure in relation to reproductive outcomes and other health endpoints in humans. Environmental Research; 2008;108:177-84.

55. Newbold RR, Jefferson WN, Padilla-Banks E. Long-term adverse effects of neonatal exposure to bisphenol A on the murine female reproductive tract. Regulatory Toxicology; 2007;24:253-8.

56. Babich MA, Chen S-B, Greene MA, et al. Risk assessment of oral exposure to diisononyl phthalate from children's products. Regulatory Toxicology and Pharmacology; 2004;40:151-67.

57. British Plastics Federation. Bisphenol-A (BPA). Position Statement [online]. London: British Plastics Federation; 2008. Available at: http://www.bpf.co.uk/Press/Bisphenol_A_BPA.aspx [Accessed 20 July 2009]

58. Ends Report. US endocrine screening tests to begin at last. Ends Report; 2009(419):24-5.

59. Ends Report. Chemical threat to men's sexual health. Ends Report; 2009(412):6.

60. Environment Agency US. Final List of Initial Pesticide Active Ingredients and Pesticide Inert Ingredients to be Screened Under the Federal Food, Drug, and Cosmetic Act. Federal Register; 2009;74(71):17579-85.

61. Phthalates Information Centre Europe. EU Risk Assessments [online]. Phthalates Information Centre Europe; 2009. Available at: http://www.phthalates.com/index.asp?page=36 [Accessed 3 July 2009]

62. Achilias DS, Roupakias C, Megalokonomos P, Lappas AA, Antonakou EV. Chemical recycling of plastic wastes made from polyethylene (LDPE and HDPE) and polypropylene (PP). Journal of Hazardous Materials; 2007(149):536-42.

63. Wikipedia. Plastic Recycling [online]. Wikipedia; 2009. Available at: http://en.wikipedia.org/wiki/Plastic_recycling [Accessed 3 July 2009]

64. Ends Report. Recession hits paper and plastic recyclate prices Ends Report; 2008(406):4-5.

65. Ends Report. Waste exports: heading for unknown destinations Ends Report; 2008(402):28-30.

66. Ends Report. Packaging targets met, but difficulties lie ahead Ends Report; 2009(411):23.

67. Recycle-more. Plastic identification chart [online]. Stratford-Upon-Avon: Recycle-more; N.D. Available at http://www.recycle-more.co.uk/nav/page689.aspx [Accessed 17 July 2009

68. Macleod C, Duarte-Davidson R, Fisher B, et al. Modelling human exposures to air pollution control (APC) residues released from landfills in England and Wales. Environment International; 2006(35):500-9.

69. DEFRA. Review of Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes. London: Department for Environment Food and Rural Affairs; 2004.

70. Yonezawa Y, Saigusa S, Takahagi M, Nishioka H. Mutagenic substances in pyrolysate obtained by burning polyvinylchloride-product at 1000°C. Mutation Research; 1999(442):97-103.

71. Li C-T, Zhuang H-K, Hsieh L-T, Lee W-J, Tsao M-C. PAH emission from the incineration of three plastic wastes. Environment International; 2001(27):61-7.

72. British Society for Ecological Medicine. The Health Effects of Waste Incinerators. 4th Report of the British Society for Ecological Medicine. Second Edition: British Society for Ecological Medicine; 2008. Available at: http://www.ecomed.org.uk/content/IncineratorReport_v3.pdf [Accessed 17 July 2009]

73. World Health Organisation. Health-care waste management. Fact Sheet no. 281 [online]. Geneva: World Health Organisation; 2004. Available at: http://www.who.int/mediacentre/factsheets/fs281/en/index.html [Accessed 18 June 2009]

74. Marine Conservation Society. Long Term Impacts of Plastic Bags in the Marine Environment - mcs policy and technical advice Ross-on-Wye: Marine Conservation Society; 2004. Available at: http://www.mcsuk.org/mcsaction/policy/+mcs+policy+and+technical+advice#pollution [Accessed 30 April 2009]

75. Galgani F, Leaute JP, Moguedet P, et al. Litter on the Sea Floor Along European Coasts. Marine Pollution Bullettin; 2000;40(6):516-27.

76. Kite-Powell HL, Fleming LE, Backer LC, et al. Linking the oceans to public health: current efforts and future directions. Environmental Health; 2008;7(Suppl 2).

77. DEFRA. Local environmental quality: Carrier bags [online]. London: Department for Environment Food and Rural Affairs; 2006. Available at: http://www.defra.gov.uk/environment/localenv/litter/bags/index.htm [Accessed 3 July 2009]

78. Friends of the Earth. Say No to Plastic Bags; N.D. Available at: http://www.foe-scotland.org.uk/Attachment/10_plastics_bags_pp.pdf [Accessed 3 July 2009]

79. Directgov. Why getting a bag habit is a good habit [online]. Directgov; 2009. Available at: http://getabaghabit.direct.gov.uk/index.html [Accessed 3 July 2009]

80. Future Bags. Plastic bags facts - the Environment [online]. Westbury: Future Bags; 2008. Available at: http://www.futurebags.co.uk/environment.asp [Accessed 3 July 2009]

81. BBC News. Plastic bag bans around the world [online]. London: BBC News; 2008. Available at: http://news.bbc.co.uk/1/hi/world/7268960.stm [Accessed 3 July 2009]

82. BBC News. China announces plastic bag ban [online]. London: BBC Nes Channel; 2008. Available at: http://news.bbc.co.uk/1/hi/world/asia-pacific/7178287.stm [Accessed 3 July 2009]

83. BBC News. Irish bag tax hailed success [online]. London: BBC News; 2002. Available at: http://news.bbc.co.uk/1/hi/world/europe/2205419.stm [Accessed 3 July 2009]

84. INCPEN. Plastic carrier bag tax - the facts. Reading: Environment ICfPt; N.D. Available at: http://www.incpen.org/pages/data/PCBFS.pdf [Accessed 3 July 2009]

85. American Chemistry Council. Recyclable Plastic Bags - Inof Sheet. Arlington: Council AC; 2009. Available at: http://www.americanchemistry.com/s_plastics/sec_content.asp?CID=1102&DID=5615 [Accessed 3 July 2009]

86. British Plastics Federation. Plastic Bag Tax - the full BPF position [online]. London: British Plastics Federation; N.D. Available at: http://www.bpf.co.uk/Press/Plastic_Bag_Tax.aspx [Accessed 17 July 2009]

87. HM Treasury. Budget 2009. Building Britain's future. London: Office TSO; 2009.

88. EPA NE. Questions About Your Community: Shopping Bags: Paper or Plastic or . . .? [online]. Environmental Protection Agency New England; 2004. Available at: http://web.archive.org/web/20041107220616/www.epa.gov/region1/communities/shopbags.html [Accessed 3 July 2009]

89. Wikipedia. Biodegradable polythene film [online]. Wikipedia; N.D. Available at: http://en.wikipedia.org/wiki/Biodegradable_polythene_film [Accessed 3 July 2009]

90. Chivian E (ed). Biodiversity: Its Importance to Human Health. Interim Executive Summary. Boston MA: Center for Health and the Global Environment, Harvard Medical School; 2003.

91. World Health Organisation. Biodiversity [online]. Geneva; 2008. Available at: http://www.who.int/globalchange/ecosystems/biodiversity/en/index.html.

THIS HEALTH + SUSTAINABILITY FACT SHEET WAS WRITTEN AND EDITED BY PAOLO LURIA

Acknowledgements:

Mary Lyons, Keith Osborn, Neil Chadborn and Penny Phillips-Howard

Centre for Public Health - Research Directorate
Faculty of Health and Applied Social Sciences
Liverpool John Moores University
Kingsway House
Hatton Garden
Liverpool L3 2AJ
Tel. (0151) 231 8146
Fax (0151) 231 8020
Email p.luria@ljmu.ac.uk

www.cph.org.uk

ISBN: 978-1-906591-94-6 (Print version)
ISBN: 978-1-906591-95-3 (PDF version)

Published September 2009

THE NEXT ISSUE WILL FOCUS ON PUBLIC HEALTH ASPECTS OF GREEN SPACE

liverpool JMU
Centre for Public Health