



# The plastic Global Challenge

*Plastic pollution is a problem that has truly 'gone global'. Fragments of plastics have been carried by planetary-scale ocean currents to the remotest corners of the world, including both Arctic and Antarctic wilderness areas. The tendency of large fragments to shatter into smaller pieces creates health hazards for sea birds and other marine organisms that swallow plastic or get tangled up in it. Action is needed at a range of scales to address the degradation of Earth's oceans and shorelines by plastic debris.*

**P**lastic is an essential material for society. It even helps us meet many of the other big 21<sup>st</sup> Century challenges that we face, for instance by providing materials that aid efforts to boost food and water production, such as polytunnels or irrigation pipes. Plastics are now part of everyday life. Toothbrushes (above), credit cards, mobiles, asthma inhalers, Lego bricks, biro: all come from plastic.

However, a third of all the plastic we use is purposely designed as 'throwaway' (with an expected

usefulness of less than one year). The economics of plastic production support this unsustainable approach to resource use: plastic is inexpensive, durable, and so is frequently designed without any intention to reuse it, as the material has low manufacturing costs attached (unlike some metals).

During the last 60 years, the amount of plastic waste has risen from 5m tonnes / year in the 1950s to 260m tonnes / year in 2010. More plastic was produced globally in the 'noughties' than during the

entire 20th Century (the start of which marked the 'birth' of plastic).

The problem has also been exacerbated by the global trade in cheap commodities driven by low wages in parts of the world such as China – as well as an insatiable appetite amongst consumers in developed and emerging economies for 'cheap and cheerful' goods such as toys, as well as for elaborately-wrapped products and bottles of water.

■ In the USA, 2 million plastic bottles are used every 5 minutes.

■ Of the 13 billion plastic liquid containers that were used in the UK alone last year, just three billion were recycled. What became of the remaining ten billion empty bottles? Many will have been destined for landfill. A significant number of others undoubtedly found their way to the Pacific Ocean, carried by run-off and sewer discharge from urban areas.

Our oceans are now full of plastic waste, some fragments of which can be dated as far back as the 1940s.

## Ocean circulation

The operation of planetary-scale surface currents and the ocean conveyor results in marine pollution quickly being spread to areas far away from the original source. Some of the remotest shorelines on the planet are now spoiled by pollution that has been carried half-way around the world (Photograph 1). Large areas of Earth's oceans are heavily polluted with plastic fragments due to the operation of **surface gyres** – circular currents in the oceans, moving clockwise in the northern hemisphere and anti-clockwise in the southern hemisphere (Figure 1).

In the north Pacific ocean, there is now a floating plastic 'garbage

patch' which is twice the size of Texas. Floating plastic objects become trapped for several years in the enormous 'slow whirlpool'. The 'plastic soup' is made up of shampoo caps, soap bottles and fragments of plastic bags. In 1999, researchers counted one million pieces of floating plastic per square mile in this area of water. This plastic pollution assumes a number of different forms:

- *Large recognisable objects* such as bottles, bottle caps, bags, broken dolls, used biro's. If ingested these can be extremely harmful to fish, birds or marine mammals. Other risks attached to these objects include the strangulation or suffocation of birds or animals.

- *Large pellets* or shards of plastic

in the early stages of physical breakdown caused by **attrition**. Newer fragments have sharp edges, older fragments are more rounded. They may still be brightly coloured which causes some birds and fish to mistake the fragments for their usual food sources such as shrimps.

- *Small pellets* of plastic that have been eroding for a longer period of time. On beaches, these particles may be the same size as grains of sand and not easily detected at first. Small manufactured pellets also enter the ocean directly – these are called 'nurdles' (Photograph 2).

- *Microplastic pellets* are the smallest detectable physical fragments resulting from further physical breakdown of plastic waste. Research has shown that waters around the north-east Atlantic are contaminated by such microscopic fragments of plastic. The abundance of this material has increased significantly over the last 40 years. Smaller than the diameter of a human hair, these tiny debris particles have been formed by the breakdown of everyday items such as plastic bags, bottles and plastic materials used in packaging.

- *Chemicals* are produced by the decomposition of some plastics in warm waters (around 30°C). Although this chemical weathering is confined to warm tropical waters, ocean currents circulate the resulting chemicals around the planet.

## Sources and sinks

Where has this refuse come from? The answer is that it has been flushed into oceans by run-off and sewer discharge from thousands of different cities all over the world. With so many origins, it becomes a very difficult pollution problem to tackle at source. Plastic is now believed to constitute 90 per cent of all rubbish floating in the oceans and the UN Environment Programme estimates that every square mile of ocean contains 46,000 pieces of floating plastic.

It would be a mistake to imagine that the rest of the world's oceans are relatively free of litter thanks to the operation of the gyres. Some studies have found microscopic plastic 'dust' to be more numerous than phytoplankton in many parts of the world's waters. Plastic dust is



Photograph 1 A polluted beach in Montevideo

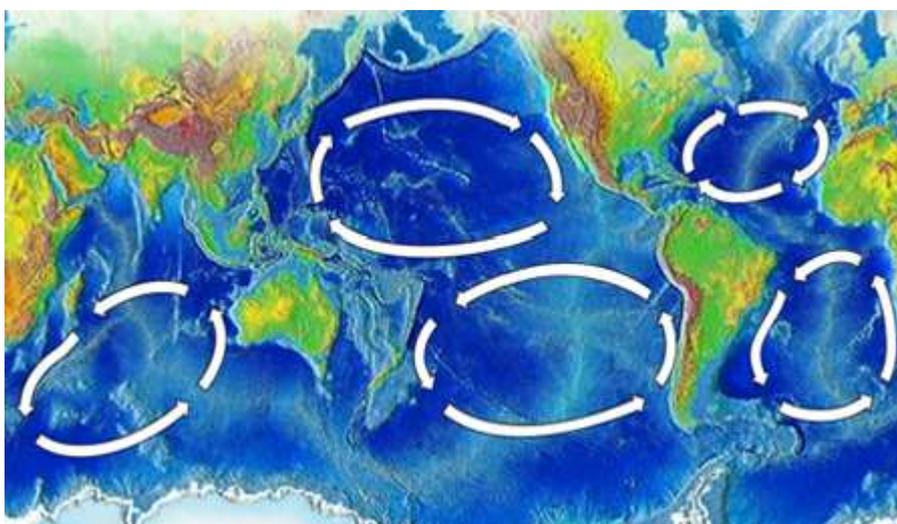


Figure 1 Surface gyre currents (Source: Wiki Commons)

## Key terms

**Attrition** A physical process that involves particles that are being carried by the wind, water or ice being broken apart into smaller and more rounded fragments. Some plastics are also broken apart by the process of photo-degradation caused by light absorption.

**Gyre** A slowly moving spiral of oceanic currents created by a high-pressure system of air currents. A gyre can form a place for ocean debris to accumulate. The North Pacific Garbage Patch is estimated to be bigger than the size of the State of Texas.

**Marine ecosystem** The term ecosystem describes a grouping of plants and animals that is linked with its local physical environment (for instance through use of soil nutrients). The oceans, covering two-thirds of our planet, are home to distinctive ecosystems composed of fish, aquatic plants and sea birds – as well as tiny but very important organisms such as krill and plankton.

**Ocean conveyor** A global ocean circulation between deep, colder water and warmer, surface water that strongly influences regional climates around the world.

ubiquitous in UK coastal waters coastal waters, for instance. The entirety of the world's oceans has been affected by this problem. The **ocean conveyor** – a 'water motorway' that runs through the entire world water system – continues to distribute and redistribute plastic waste all around the planet.

In addition to the garbage patches, some high-profile discoveries of plastic pollution have been made in important wilderness regions:

■ Dr Simon Boxall, lecturer in Oceanography at the University of Southampton, made the worrying find of a high level of plastic rubbish on a remote Arctic island over 1,000km from the nearest town or village, carried there from polluting countries all around the world by ocean currents. Muffin Island is one



**Photograph 2** 'Nurdles' on a beach

of the most remote places on planet, yet plastics from Norway, Spain and the USA litter its beaches. This is a pollution problem does not respect boundaries.

■ Plastic pollution of the Hawaiian islands, such as Tern Island, has been widely filmed and studied - and provided an important stimulus for the recent consumer-led drive to reduce plastic bag dependency amongst UK shoppers.

## Marine ecosystems

Pollution can have damaging effects on **marine ecosystems** and may reduce biodiversity. In recent years, scientists have become increasingly concerned with the impacts of plastic pollution on marine species and food webs. Data on sea birds showing the ingestion of plastic waste as being a cause of death first began to appear in the 1950s. 95% of dead fulmars (a common sea bird) washed ashore in

Scotland will have some plastic debris in their gut. Worldwide, 260 species bird and mammal are known to ingest or become entangled in plastic wastes (Photograph 3).

■ Discarded red lids from water bottles are a particular problem – in size and colour they mimic the appearance of the krill shrimp that albatross eat. Autopsies have shown an abundance of red-coloured debris in the gut of dead albatross birds.

■ Plastics sometimes undergo chemical decomposition at a molecular level in warm tropical waters. This can result in the release of a chemical called bisphenol A (BPA). Japanese researchers have found that some samples of sea water contain up to 50 ppm of BPA. This can become a problem because BPA functions as an endocrine disruptor (especially for organisms higher up the marine food chain) – which impairs reproduction.

■ All direct impacts on one marine species will indirectly impact on other species due to the way that marine food webs function.

## What solutions exist?

The size and scale of this problem makes it an enormous global challenge. Action needs to be co-ordinated amongst the world's producers of plastics as well as consumers in every country on the planet. There is also an important role for government at varying scales in helping to regulate consumer and



**Photograph 3** Dead sea bird on Tern Island, Hawaii

Solution	Advantages & disadvantages
<b>Business-led initiatives</b>	<ul style="list-style-type: none"> <li>• Direct ways of tackling the problem may lie with the plastics industry itself. ‘Plastics 2020’ is a new UK initiative dedicated to diverting a greater volume of used plastics waste out of landfill and into recycling facilities. However, this action relates to just one country – and there are a growing number of big polluters all around the globe. Also, any initiative, no matter how ambitious, cannot undo the damage already done.</li> <li>• Retail businesses in the UK and other countries have recently begun to deter the use of throwaway plastic bags by using a range of incentives. In the UK, much of the early impetus came from a BBC camerawoman, Rebecca Hosking, a nature documentary maker who has seen first hand the devastating effects of plastic carrier bags on marine life. In Hawaii, she witnessed scores of animals and birds being choked to death by the plastic bags which had washed ashore. She spearheaded a campaign amongst retailers in her home town of Modbury that then spread nationally.</li> </ul>
<b>Regulation</b>	<ul style="list-style-type: none"> <li>• Government restrictions on use of throwaway plastic bags now exist in China and Bangladesh, where the use of thin (&lt;0.025mm thickness) plastic bags has been prohibited at the highest level. These small bags have been blocking watercourses and sewers in these two nations, greatly exacerbating flooding, especially during the monsoon season. Densely populated Taiwan, which is running out of landfill space, has not only banned bags but has also stopped fast food restaurants and supermarkets issuing plastic knives, forks and cups. Like Hong Kong, the Taiwanese government also makes supermarkets charge for bags.</li> </ul>
<b>Awareness-raising exercises</b>	<ul style="list-style-type: none"> <li>• ‘Plastiki’ is an innovative sailing vessel built with 12,500 used plastic bottles for buoyancy. David de Rothschild, founder of Adventure Ecology, established its mission: to sail across the Pacific Ocean and through the garbage patch – and to catch the eye of the global media, raising awareness of the pollution problem. From March to July 2010, David and a crew of five undertook the expedition.</li> <li>• ‘Plastic bag’ is a short film by American director Ramin Bahrani that traces the epic journey of a plastic bag (voiced by Werner Herzog) searching for its lost ‘maker’ (the woman who took it home from the store and eventually discarded it). One review describes it as follows: ‘The result is a film that is a success as education and entertainment, that musters a startling amount of pathos from its subject and a surprising amount of empathy from its audience.’ The epic music (especially so in the closing sequence) is written and performed by members of cult Icelandic band Sigur Ros. <a href="http://deagosto.com/2010/04/16/plastic-bag/">http://deagosto.com/2010/04/16/plastic-bag/</a></li> </ul>

Table 1

producer behaviour (Table 1).

The key problem seems to be the worldwide under-valuing of plastic waste - and a lack of incentives either for consumers to recycle, or for manufacturers to make greater efforts to ensure that their products can be easily recycled or reused. An attitudinal shift is needed to reduce global society’s current ‘linear’ use of oil, wherein 8% of world oil production goes into plastics each year - one third of which is subsequently thrown away. Recycling of *all* plastics would replace this unsustainable linear usage model with a sustainable system. Actions to bring about behavioural change need to target both producer and consumer groups.

## Key Points

- Cheap manufacturing of plastic goods and wrapping has accelerated, partly due to globalisation and the global shift of manufacturing to low-wage economies.
- This has encouraged a ‘throwaway’ mentality for many consumers.
- Ocean currents are responsible for turning local pollution problems into global problems.
- Plastic pollution of Earth’s oceans is a major global challenge that brings a range of negative impacts for marine ecosystems and wilderness environments.
- There are no easy solutions but action is now being taken by a range of players and at a range of scales.

*Written by Simon Oakes (2010). Content information based on lectures and interviews with Simon Boxall, Charles Moore and Richard Thompson. Images are re-produced under Flickr Creative Commons license. Main photograph by Krossbow of plastic toothbrushes found at Geneta Bay in Queensland; Photograph 1 by Vincealongi; Photograph 2 by Sustainablecoastlines; Photograph 3 by Angrysunbird.*