



Plastics: challenges for the water environment

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1. Summary

Plastics have grabbed people's attention. Recent media coverage has made society ask 'what more needs to be done to reduce plastics entering the ocean?' It is also important to turn our attention to plastics in the freshwater and soil environments. There are issues caused by visible plastic contamination of beaches, rivers and soils, and in the ingestion and entanglement of wildlife. There is also increasing concern about the potential impacts of micro-plastics in soils, air, the water environment, the food chain and on human and plant health.

The government's 25 Year Environment Plan sets out ambitious plans:

- to reduce avoidable plastic waste
- for the plastic we use to be fully reused, recycled or compostable
- to prevent micro-plastics reaching the seas

There are many justifiable uses of plastic. For example, it is an essential component of flood defences and in medical equipment. The alternatives can also be damaging to the environment. However, there is considerable political and public expectation for action. The public, the Environment Agency, government and industry need to understand the emerging issues and take decisive action to reduce waste plastics entering the environment.

2. Chemical pressures - sources, pathways and fates

2.1 Types of plastic

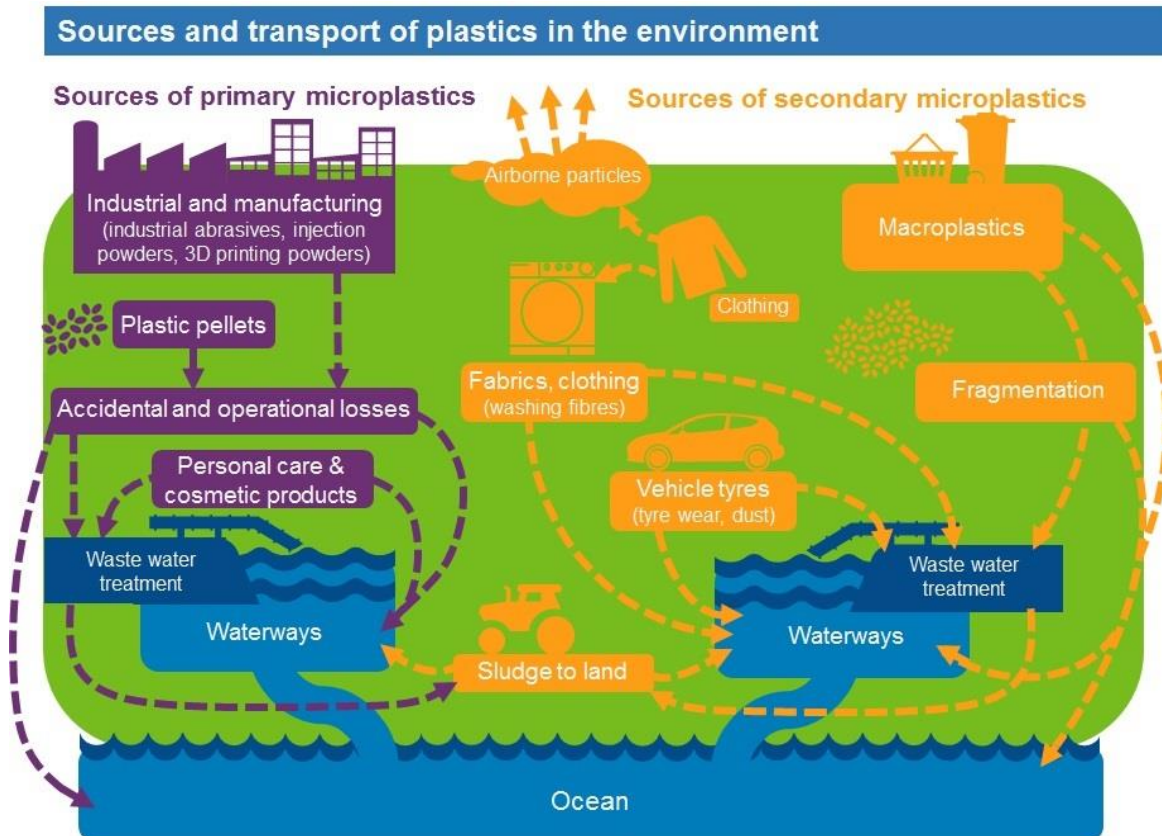
Plastic mainly enters the environment either as large pieces (sometimes referred to as macro-plastics) or in small particles (micro-plastics). Macro-plastics can degrade to produce what are known as secondary micro- or nano- plastics. The plastic can be emitted to air, water or deposited on land and there will be pathways between these media.

Although there is no consistent definition for micro-plastics they include nurdles (pre-production plastic particles), plastic bio-beads (used industrially, including in sewage treatment) and small plastic particles (less than 5mm diameter). Micro-plastics also arise from textile fibres, tyre and road wear particles, and the breakdown of litter and other macro-plastics.

Nano-plastics are a subset of micro-plastics comprising the smallest particles. While there isn't a formal definition, generally this includes plastic particles less than 1 μm diameter. The term plastics encompass a wide range of materials of varying chemical compositions, sizes and shapes.

The sources and transport of plastics in the environment can be seen in Figure 1. Primary microplastics from industry and manufacturing, plastic pellets and cosmetics enter the water directly and into sludge. Secondary microplastics enter watercourses through clothes washing and vehicle use. Macroplastics also enter waterways directly and through waste water treatment.

Figure 1: sources and transport of plastics in the environment



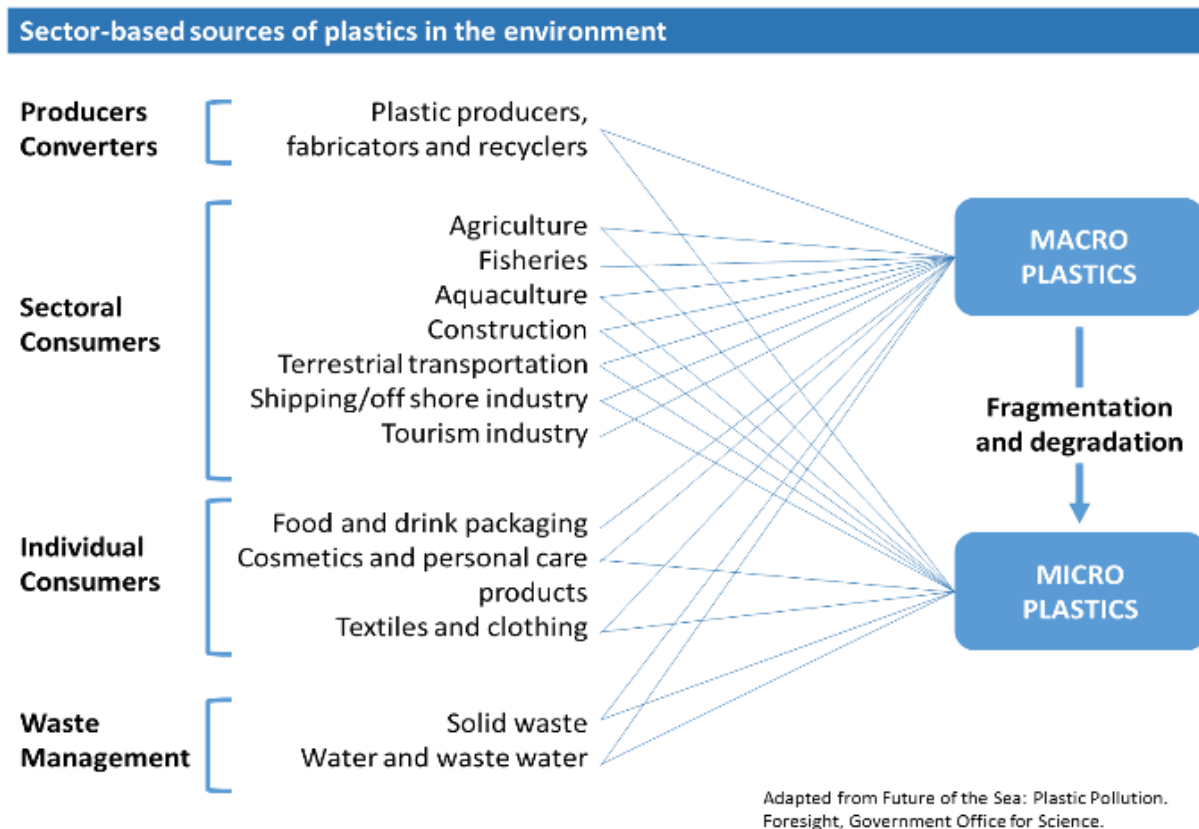
Adapted from: UNEP 2016, Marine plastic debris and microplastics.

2.2. Understanding the scale of the problem

The sheer amount of plastic used globally coupled with low recycling rates and the propensity to litter plastics like food wrappings means that plastics have entered the environment in large quantities.

Despite a growing number of studies we are some way from having a reliable understanding of how much plastic pollution comes from specific sources, or its distribution at a catchment level. It is not yet known what the largest sources of plastics into the environment are which makes it more difficult to pursue options to target the most polluting or the most harmful activities. Sector-based sources of plastics in the environment are shown in Figure 2. A range of sectors belonging to producers (plastic producers/fabricators), sectoral consumers (for example shipping, fisheries and agriculture), individual consumers (packaging, cosmetics products and clothing) and waste management (solid and water waste) are shown. The majority of sectors produce both macro and micro plastics.

Figure 2: Sector-based sources of plastics in the environment



Concerns about the floating islands of plastic in the world’s ocean were further highlighted by a study that estimated the sources and volumes of waste plastic entering the sea. The study estimated that between 4.7 and 12.8 million metric tonnes of plastic enters the world’s ocean every year (Jambeck et al, 2015). The study was based on assumptions about populations living within 50km of the coast and the quality of waste management systems. It is likely to be a conservative estimate.

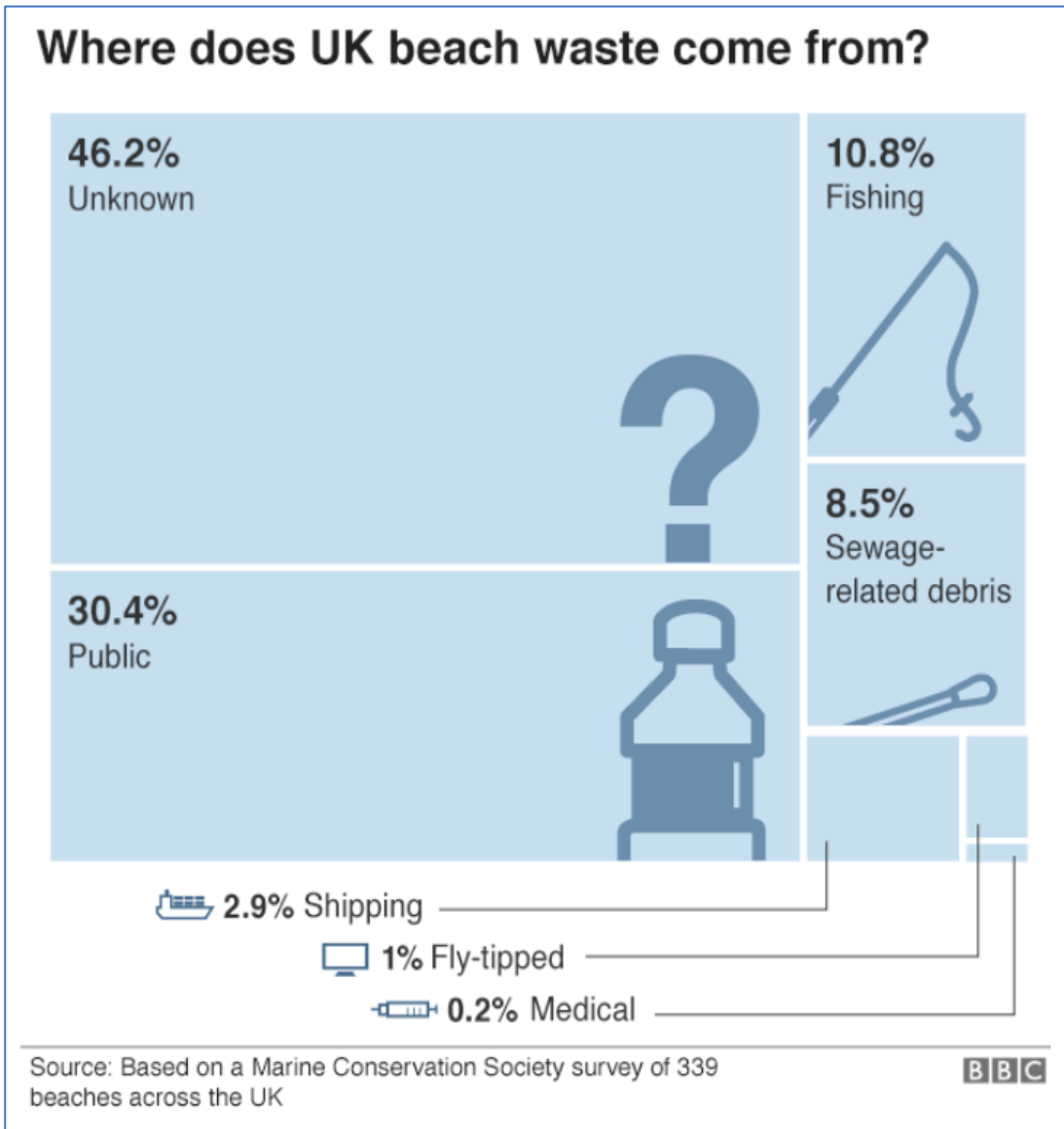
This and other studies (for example Lebreton et al, 2017) suggest that 85% of the plastic entering the ocean comes from Asia. Therefore, the contribution to global ocean plastic litter from countries like England, that have well developed waste management systems, is likely to be relatively small although this does not negate the importance of domestic sources entering rivers and found on the coastline. Understanding where there are opportunities to contribute to its reduction are important not least in understanding how to manage plastic pollution.

From the recent UKWIR study ‘Sink to River – River to Tap’, we know that in the UK, 99.99% of micro-plastics are removed from sewage effluent by waste water treatment processes. This means that micro-plastics are present in sewage sludge which is spread to land.

Additionally, plastic litter found on beaches and elsewhere in the environment affects people’s enjoyment and tourism and can entangle or be ingested by wildlife. Figure 3

shows that almost half of plastic beach waste comes from unknown origins, but that nearly a third is sourced from members of the public. Fishing and sewage related debris make up around 20% of plastic on beaches. The items which contribute to these figures are shown in figure 4. Cigarette butts account for 18% followed by larger plastic pieces at 8%. Smaller plastic pieces, plastic cups and cotton buds each account for 5%. Cotton buds, shopping bags and crisp packets are also found at around 4% each followed by string and drinks bottles.

Figure 3. Source of plastics on UK beaches (MCS Survey)

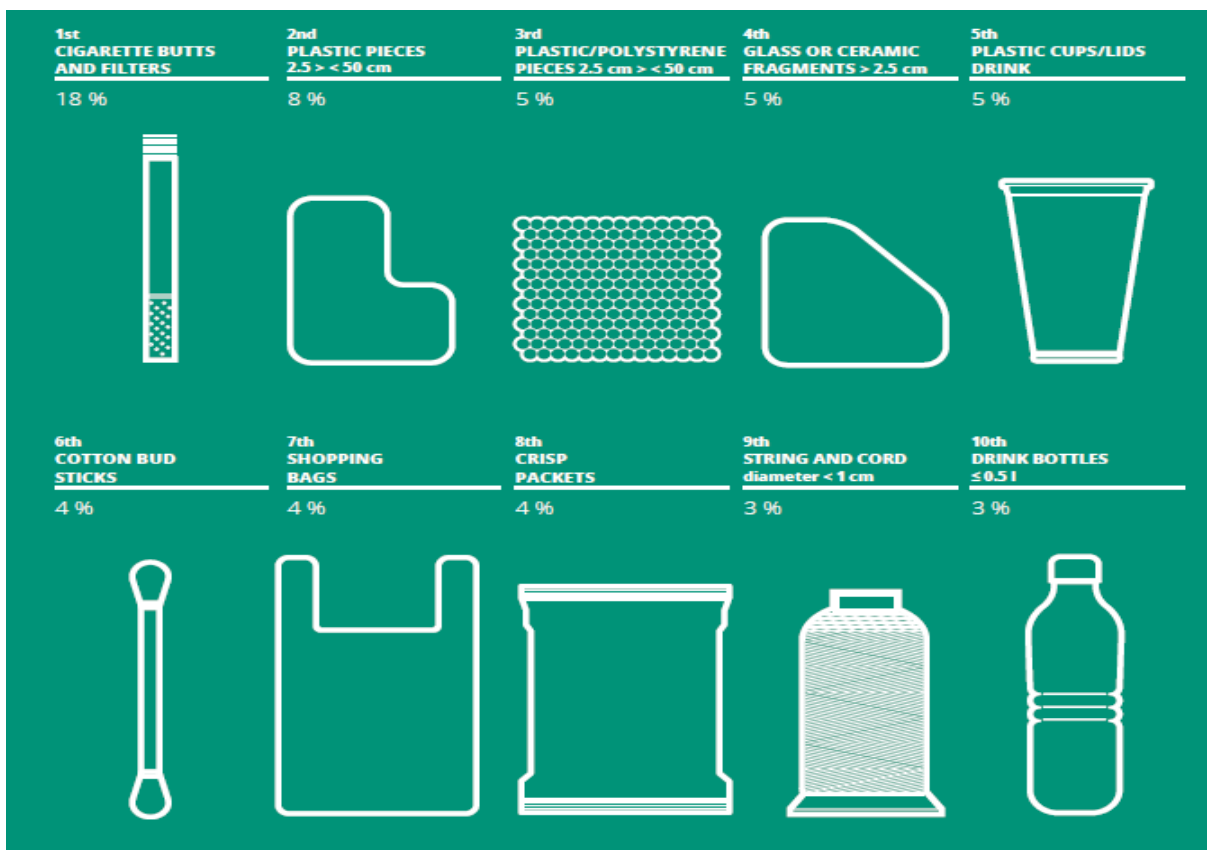


Data for figure 3

Source	Percentage
Unknown	46.2%
Public	30.4%

Source	Percentage
Fishing	10.8%
Sewage-related debris	8.5%
Shipping	2.9%
Fly-tipped	1%
Medical	0.2%

Figure 4. Common plastics items found on European beaches. Source: Marine Litter Watch 2018 Report, European Environment Agency.



Data for figure 4

Plastic item	Percentage
Cigarette butts and filters	18%
Plastic pieces 2.5cm > < 50cm	8%

Plastic item	Percentage
Plastic/polysterene pieces 2.5cm > <50cm	5%
Glass or ceramic fragments > 2.5cm	5%
Plastic cups/lids drink	5%
Cotton bud sticks	4%
Shopping bags	4%
Crisp packets	4%
String and cord	3%
Drink bottles	3%

2.3 Impacts on people and the environment

The impact of these plastics on the environment, on the food chain or on our health is not yet well understood.

Visible pollution is clearly objectionable. Large accumulations create costly obstructions in waterways and disrupt coastal activities and businesses. There is widespread evidence that plastic causes harm through entanglement and ingestion to a wide range of wildlife. The effects of this beyond individuals is unclear so that population scale effects are unknown.

Laboratory studies have shown that micro-plastics can be ingested by plants and animals, including fish and earthworms, and that at high concentrations these can cause harm. In general, these high concentrations are not likely to occur in the environment although data on the actual concentrations of plastic in water, soils and air are few. Based on limited environmental measurements, the current levels of micro-plastics in the environment are below the levels shown to cause harm in laboratory studies (SAPEA, 2019).

Most micro-plastics, like many chemicals, pass through organisms. Adverse effects depend on the dose although there is insufficient evidence at present to develop risk based approaches. Most plastic polymers include additives to improve their function or lifespan. For example, plasticisers are added make them durable or malleable and stabilisers or anti-oxidants are added to stop the plastic breaking down. Recent analysis indicates there are over 400 substances used as plastic additives (European Chemicals Agency ECHA (2018) <https://echa.europa.eu/plastic-additives-initiative>). The potential for

these additive chemicals to be released from plastics into the environment, is not yet understood.

However, the increasing volume of plastic in the world's ocean (a combination of increased production and lack of degradation) will obviously increase the potential for population scale effects to occur. It is also important to note that the current lack of evidence of serious harm to human health, the food chain or the environment is not the same as no effect.

Better understanding the effects on wildlife is an important research gap. However, studies on the potential impacts on human health and ecosystems are likely to take a number of years. The absence of the whole picture is not a reason for current inaction and the precautionary principle supports action to reduce the further release of plastics to the environment. We, alongside many others in society, are taking action to ensure our various interventions, including regulatory, are effective in this respect.

2.4 Nano-plastics and human and environmental health

There is a concern that the smallest plastic particles (often described as nano-plastics) may cross cell membranes and lead to adverse biological impacts (Browne et al 2015). Some research on nano-plastics shows potential damage in mussels (Brandt, et al 2018) but there is no clear link to effects on the human food chain and it is hard to know how relevant the concentrations of plastic are in the experiments. There is no current method to measure the presence of nano-plastics within the cells of organisms or the environment and so the risk from this size fraction of plastic is unquantified at present. The absence of standard analytical methods for the measuring and monitoring of different size fractions of plastic particles is an important challenge for understanding the environmental effects of micro-plastics.

2.5 Plastic as a pathway

The theory of micro-plastics as 'vectors' for chemicals adhered to their surface is a possibility but there is insufficient evidence to demonstrate it occurs in the real world. In addition, current research indicates that such an exposure pathway is likely to be of limited importance relative to other food and water exposure.

It is now clear that people also ingest plastics (Liebmann et al, 2018). Concern about this aspect is driving research so that more evidence may become available over the next few years. The potential for effects from air-borne plastic particles on human health are also unknown. Plastic particles emitted to air may be linked with other pollutants and particles (such as from industrial processes and traffic pollution) and so the contribution of the plastic to any health effects may be difficult to identify separately. Concern has also been raised about the potential for plastics to be pathways or pathogens although again there is no evidence of this risk to date.

3. Addressing the problem

3.1 Environment Agency as regulator

Through our statutory duties as a regulator, we already have mechanisms to manage plastic pollution at several stages of manufacture, use and disposal.

Our roles in regulation include:

- waste management
 - waste to land
 - plastic waste recycling
 - disposal (landfill and Energy from Waste)
- definition of waste and when 'end-of-waste' status is met
- producer responsibility for packaging
- plastic manufacturing
- chemicals
- trans-frontier shipments
- crime in the waste sector
- wastewater treatment and materials spread to land

The maturity and effectiveness of the regulation varies between the different sources of plastic. For example, preventing windblown litter from waste management facilities is controlled by the environmental permit and has been a part of our compliance activities for decades. In contrast, the presence of micro-plastics in waste spread to land is not specifically covered by permit conditions and so our current regulatory control of this source is limited.

We regulate installations which produce the materials for plastic products and we will have a role in supporting new methods of production as new materials are developed in response to the reduction in single use plastics. Our permits ensure that these installations are not significant sources of plastic emission to the environment. We also work to reduce the release of small plastic pellets from the industries we regulate. This includes plastic used in waste water treatment and the industrial tube-cleaning products that are used in the Nuclear Industry and the Thermal Combustion Sector.

We regulate exported waste to ensure it goes to a reputable facility where the plastic can be recovered. We use the Materials Recovery Facilities Regulations (MRF) to work with the larger materials recycling facilities; monitoring contamination in recovered plastic and recycling rates. We are working to understand the implications of biodegradable plastics for our regulatory role. We're also working with biowaste and other operators to reduce the visible plastic contamination in materials and other wastes spread to land.

3.2 Initiatives and partnerships

We are working with others to investigate sources, pathways and impacts rather than starting our own monitoring programme at this stage. We are using a growing number of studies to provide us with a view of sources, pathways and amounts of plastic to inform our work.

3.2.1 Data

Gaining comprehensive data about the scale of micro-plastics in the environment is currently hampered by the fact that there are no consistent sampling and collection or assessment methodologies for measuring micro-plastics in various media (sediments, water column or biota) although many are being developed and used. An important aspect of our work is collaborating with Defra, academia and water companies to achieve greater harmonisation over sampling and assessment methodologies, definitions and outcomes for monitoring micro-plastics in the environment.

3.2.2 Evidence

We are seeking evidence to understand the extent of risk that plastic pollution poses to our health and the wider environment. To gather this evidence we are working with government, partners and various academic institutions on an investigatory research basis. We've developed a set of research questions to help the academic community understand our end-user needs. This evidence will enable us to target our interventions and initiatives. We are gathering evidence from:

- many academic research studies are investigating the relative contributions of various sources of micro-plastics as well as their pathways, transfer and fate through the ecosystem and flows at a catchment level
- highways England is leading research on understanding micro-plastics from the major road networks
- Defra published Plymouth University research into tyre wear and textile particles and their pathways in the environment
- Cefas (Centre for Environment, Fisheries and Aquaculture Science) are developing a programme to measure micro-plastics in marine sediments and marine life
- Cefas are partners in the Clean Atlantic project examining the monitoring, modelling and management of marine litter in the Atlantic area
- Natural England are working with Newcastle University to investigate the interactions of micro-plastics with plankton in North East England
- Natural England have used various data to investigate the amount of marine plastics found in Marine Protected Areas
- Defra sponsor a long term monitoring project looking at the ingestion of plastics by fulmars
- European LRi (Long-range Research Initiative) are undertaking projects in collaboration with other global regulators and industry scientists

- we're working with water companies, UK Water Industry Research (UKWIR) and WaterUK to investigate the role wastewater treatment and sludge disposal provide as a pathway for micro-plastics to enter the environment and consider how best to target preventative measures, preferably at source
- UKWIR are developing a roadmap to frame future research needed to better understand the micro-plastics issues in the water sector
- the Drinking Water Inspectorate have commissioned research into how micro-plastics can be removed from drinking water processes

Everyone can get involved too and contribute to Scottish environmental charity Fidra's 'The Great Nurdle Hunt' initiative.

Matt Wheeldon of Wessex Water has said:

“Awareness and understanding of sources, pathways and receptors of micro-plastics plus the consequences of this type of pollution on the health of mankind and the planet is recognised as a vital research area required in order to develop solutions to a truly man-made problem.

The water industry has a key role in protecting public health and the environment and they provide and operate assets that act as important pathways for such micro-plastics. In a few localised places, where plastic media is used as part of treatment processes, they could also be considered a potential source.

This is truly a whole society problem and partnerships between government, government departments, NGOs and private companies are key to solve this global issue. The water industry is keen to play its part in protecting human health and the environment and its collective body (WaterUK) and collaborative research establishment (UK Water Industry Research) are involved in establishing the scale of the problem and recommending the best solutions to it.”

3.2.3 Government policy and initiatives

Our work is informed by government policy initiatives. These policies are aimed at strengthening the circular economy for plastics, reducing the amount of plastic waste produced and preventing it escaping into the environment:

- UK government ban in 2018 on the sale and production of personal care products containing micro-beads
- UK government brought in a ban in October 2020 of the supply of plastic drinking straws, stirrers and cotton buds to the end user
- Defra are implementing their Litter Strategy to reduce plastics entering the environment
- Defra's Resources & Waste Strategy together with BEIS and Treasury policy and financial initiatives set out the ambition and recommendations for a circular economy for plastics:

- invoke the 'polluter pays' principle and extend producer responsibility for packaging, ensuring that producers pay the full costs of disposal for their packaging
- stimulate demand for recycled plastic by introducing a tax on plastic packaging with less than 30% recycled plastic
- ban plastic products where there is a clear case for it and alternatives exist
- improve recycling rates by ensuring a consistent set of dry recyclable materials is collected from all households and businesses
- improve the quality of plastics exported for recycling through the Basel and Stockholm Conventions
- ran a call for evidence on the development of standards for bio-based and biodegradable plastics

Initiatives to reduce the accidental spillage of pre-production plastic pellets, flakes and powders across the supply chain include:

- Operation Clean Sweep; a voluntary scheme that provides a framework of best practice preventing the loss of plastic pellets, flakes and powders across the supply chain from producers to users
- British Retail Consortium's Global Standards now include pellet management within their revised packaging standard

3.2.4 Protecting soil health

Various initiatives are being developed to prevent plastic contamination of soils and protect soil health from materials spread to land:

- we are working with the National Farmers Union (NFU), farm assurance schemes, Chartered Institute for Waste Management (CIWM) and biowaste operators and their trade associations to understand potential options to reduce micro-plastic contamination in soils
- we've launched an EA Sludge Strategy to review pressures and risk around sewage sludge from its production through treatment and disposal
- Biowaste Regulatory Forum includes membership from the waste and water industries, NFU, Defra, CIWM and biowaste trade associations, such as Renewable Energy Association Limited (REAL), Anaerobic Digestion Bioresources Association (ADBA), Bio-Based Industries Association (BBIA) and Waste & Resources Action Programme (WRAP) and has four industry led themes:
 - containment
 - competence
 - compliance
 - contamination run by the Renewable Energy Association, includes a campaign being run to 'Say No to Plastic' and Biowastes and Plastics in Soils: A Position Paper and Summary.
- we're exploring the ability to tighten plastic contamination limits for materials spread to land including composts and digestate, to improve compliance with

existing standards and controls and to improve permitting controls for biowaste facilities

Jeremy Jacobs of Renewable Energy Association said:

“The greatest emphasis for me and more importantly Organics Recovery Group (ORG) is to reduce the volumes of plastic that find their way into the biodegradable resource streams especially garden waste (but also food waste). Removing this is costly and not entirely effective, resulting in the inevitability of plastics reaching soils and the food chain.

Greater education of the public and improving behavioural change is a priority if we are to make the difference.

Protecting our land bank is essential for the future as well as the now!”

3.2.5 Industry initiatives

Industry is developing and implementing best practice initiatives to reduce accidental release of small plastic beads used in treatment and cooling water processes:

- nuclear industry – voluntary improvements were implemented around 2013 which minimised losses although there is likely to be a significant reservoir of beads on the seabed which will continue to wash up
- thermal combustion- industry quickly made the necessary improvements to prevent releases and are required to notify us if any further releases occur. We are working with industry on best practice guidance for use of Trapogge balls in cooling systems
- collaborative working with water companies to prevent the loss of plastic media from their treatment processes into the environment

3.2.6 Business initiatives

Business-led initiatives to reduce plastic used, increase reuse and recycling the plastics used while preventing losses to environment include:

- WRAP & Ellen MacArthur Foundation’s UK Plastics Pact; a voluntary business led initiative to reduce plastic packaging
- Business in the Community’s Circular Economy Taskforce
- Fishing For Litter- providing port waste reception facilities to encourage fishermen to bring back lost or discarded fishing gear
- The Global Ghost Gear Initiative is a partnership of the fishing industry, private and third sector, academia and governments tackling the issues of lost and abandoned fishing gear and various smaller circular systems whereby ocean plastics are collected and turned back into plastic pellets and products, such as canoes made from these recycled plastics

Helen Bird from WRAP has said:

“The UK Plastics Pact, led by WRAP: a collaborative approach to tackling plastic waste through four targets to 2025:

- eliminating problematic and unnecessary plastic packaging items
- 100% of plastic packaging to be re-usable, recyclable or compostable
- 70% of plastic packaging to be effectively recycled
- 30% average recycled content across plastic packaging

Members of The Plastics Pact represent 85% of plastic packaging sold through supermarkets and cover the whole value chain. Members of The Pact are working at pace to address the urgent issue of plastic waste. However, one of the challenges is to ensure that any moves away from plastic are considered carefully in order to avoid unintended consequences which could lead to increased greenhouse gas emissions. Citizen engagement is also a key part, particularly to motivate and educate on recycling through Recycle Now.

3.2.7 Agriculture

Initiatives in the agricultural sector are looking at ways to reduce the use of farm plastics, promoting reuse and recycling to reducing inadvertent release into soils and water:

- we’re working with all farm assurance scheme providers to promote better farm waste practices
- we are working with NFU to promote their advice on better farm waste management. NFU have linked up with a number of agricultural waste collectors and re-processors to see how this sector can collaborate to achieve more recycling and reuse of farm waste plastics

Anna Simpson from Waste Policy Advisor NFU has said:

“Farmers use a wide range of plastic products and packaging within the work place. This plastic can often be contaminated, heavily soiled or in small quantities. This alongside recent export bans to Asia is making it difficult to get farm plastic collected and recycled from farm. Established collection and recycling networks need to be supported and domestic solutions encouraged and supported by government. There are few alternative options for farmers to deal with these waste streams and landfilling separated plastic seems perverse.”

- we’re working with RSPCA Assured (part of the RSPCA) to review how their farm assurance scheme can promote better use of plastics on farms and in food packaging

Liam Kurzeja, Head of Marketing RSPCA Assured has said:

"It's becoming increasingly apparent that we need to take a more holistic approach to what we do. Although we are a farm animal welfare certification scheme, we feel we also need to focus on the wider implications of farming and food production for wild animals and the environment.

The goal for us is to be able to support our scheme members to boldly engage with plastics issues, and ultimately to help them capitalise on their positive actions."

3.2.8 Europe

The European Chemicals Agency (ECHA) has reviewed and reported on intentionally produced micro-plastics.

3.2.9 Third sector

Various initiatives are led by the third sector, charitable and community based organisations:

- Surfers Against Sewage - Big Spring Beach Clean, Plastic Free Communities, Businesses and Schools
- Marine Conservation Society - Beach Watch annual survey and beach cleaning campaign, Sea Champions and Plastic Challenge
- Keep Britain Tidy - Great British Spring Clean & Litter Heroes and behavioural insights research
- #BinIt4Beaches campaigns: partnership involving the water sector and a range of organisations, including Keep Britain Tidy, Marine Conservation Society, Surfers Against Sewage, water companies and others to raise awareness to prevent plastics being flushed down the drains
- 6% of items found on the @MCSUK Great British Beach Clean 2018 were associated with items flushed down the loo. Wet wipes, tampon applicators and cotton buds nearly always contain plastic

4. References

[The Great Nurdle Hunt](#)

[Say No to Plastic](#)

[Biowastes and Plastics in Soils: A Position Paper and Summary](#)

[Recycle Now](#)

Appendix 1: Plastic issues in industries regulated by the Environment Agency (for macro plastics >5mm)

Plastic production issues

Source 1: Manufacturing of plastic packaging

Regulation: Producer responsibility and extended producer responsibility. EPR permits are regulated sites. Plastics tax on recycled content in new products?

Issues/aims: Increase recovery and recycling, reduce excess packaging. Reduce virgin raw materials used. Contribution from imports.

Source 2: Manufacturing of other plastics

Regulation: Largely not regulated by the EA – any loss of pellets managed through Duty of Care (DoC). EPR permits at regulated sites – prevent any loss.

Issues/aims: Increase recovery and recycling. Contributions from imports. Textiles could be a candidate for extended producer responsibility.

Use and consumption issues

Source 1: Littering, often windblown. Delivery discarding for example food packaging, fishing gear at sea. Litter from regulated sites.

Regulation: Littering is key focus and we can support local authorities and non government organisations. EPR permits at regulated sites – DoC compliance Defra Litter Strategy and marine protocols.

Issues and aims: Plastics in the environment. Obstruction of waterways. Visually objectionable – can affect for example tourism. Effects on wildlife for example entanglement. Social/ethical issue for example Pacific garbage patch.

Source 2: Visible plastics in reused wastes for example materials (compost, AD digestate) spread to land, in recycled aggregates and U1 exemptions.

Regulation: Quality protocols with PAS standards; permitting inputs and output controls.

Issues/aims: Contamination issue, possible ingestion by animals. Reduces landowners willingness to accept waste for spreading. Aesthetic issue.

Source 3: Taprogge sponge balls used for pipe cleaning; nuclear and combustion industries.

Regulation: IED & EPR permit prevent losses in discharges and abatement. Best practice guidelines. Industries required to monitor and report losses. Other sectors we regulate may use plastic media in their effluent treatment – also limit this loss.

Issues/aims: Losses enter waterways. Small balls will erode to become micro-plastic size or lose micro-plastics.

Waste management issues

Source 1: Recovered plastic. (Waste treatment sectors EfW)

Regulation: Quality protocols. Materials Recovery Facilities (MRFs) reporting under EPR. EPR permits at regulated sites. Hazardous chemicals regulations

Issues/aims: Increase recovery and recycling; reduce plastic waste going to landfill. Prevent stockpiling. Contamination reduces recovery options – design out chemical additives.

Source 2: Exported waste.

Regulation: International waste shipments. Assessment of overseas facilities for receipt of packaging waste.

Issues/aims: Sufficient acceptable overseas facilities? Quality – contamination and increasing export restrictions; risks stockpiling in the UK. Accidental spillages from shipping.

Waste mis-managed

Source 1: Fly tipping

Regulation: DoC on householders disposing of waste. EA responsibility for large or hazardous cases.

Issues/aims: Obstruction, visually objectionable. Effects on wildlife.

Source 2: Waste crime and illegal waste sites.

Regulation: Enforcement action on improperly stored, handled or disposed plastic. Powers to block entry, seize vehicles and enforce clean up.

Issues/aims: Obstruction, visually objectionable. Effects on wildlife.