<u>Are Micro plastics a Problem Within the Solent that Needs to be Addressed?</u>

Abstract

This report looks at how microplastics may affect wildlife and habitats within the Solent. An overview of the work by Antony Gallagher (2016) looking at microplastics within the Solent estuarine complex will show the spread of plastics across the Solent and possible sources that may need further research. A wide range of research is identified from around the world looking at different species and habitats and how microplastics affect them. This research is then related back to the Solent area to assess weather these microplastics are causing problems for species and habitats.

Plastics History

Since the first plastic was created in 1907, there have been many advances to create more durable, corrosion resistant materials (Plastics Europe 2010). Due to this, there are now many plastic materials which are unable to break down and therefore become a problem to marine environments. Since 2009, the production of plastic has accounted for 8% of the global oil production (PlasticsEurope 2010) and this has turned an aesthetic problem of litter on beaches to a more serious environmental issue. There are three types of plastic, macro (>20mm diameter), meso (5-20mm diameter) and micro comes below 5mm diameter (Barnes et al 2009). When macro and meso plastics enter the environment they can break down to create secondary microplastics which are extremely harmful to species and habitats (Ryan et al 2009; Thomson et al 2004). Primary microplastics are man made to be this small. There are different types of primary microplastics: micro-beads and microfibers. Micro-beads are the small fragments of plastic found in cosmetics such as exfoliates and toothpastes. Micro fibres are found in polyester clothing and ropes which can be used for fishing. The plastics fibres are used to make the material stronger but when clothes are washed and ropes enter the ocean, these fibres break off and enter the water system.

Microplastics are microscopic fragments that are able to get into the oceans and water systems by getting through water filtration systems. This is where the problem begins - it allows them to become part of the food chain and be passed through trophic levels (Andrady 2011) along with entering natural habitats and causing harm to the environment.

Where they come from

Plastics are created in factories on land and then make their way to the sea by many different routes: Litter from the coast, fishing equipment, illegal dumping, material flowing in rivers, drainage from storm water and sewage waste (MCS Beachwatch 2005). Around four fifths of plastic debris found in the ocean comes from land and one fifth from deposition off boats.

Movement of Microplastics within the Five Gyres

Plastics can drift in the oceans for thousands of years before sinking to the sea bed. They move around in ocean currents and get caught in ocean gyres. There are five main gyres in the global ocean system which accumulate litter and keep it there for long periods of time (Figure 1). These five gyres act as garbage heaps for all sorts of rubbish found in the ocean. The rubbish collects here due to calm waters surrounded by a circular flow. It is around these gyre systems that the microplastics pollution is at its most serious. There has been a large amount of research around microplastics in species and habitats around the coasts of North America suggesting this area has a large scale of microplastic pollution. The North Pacific Gyre has been researched in particular showing large amounts of species and habitat pollution.

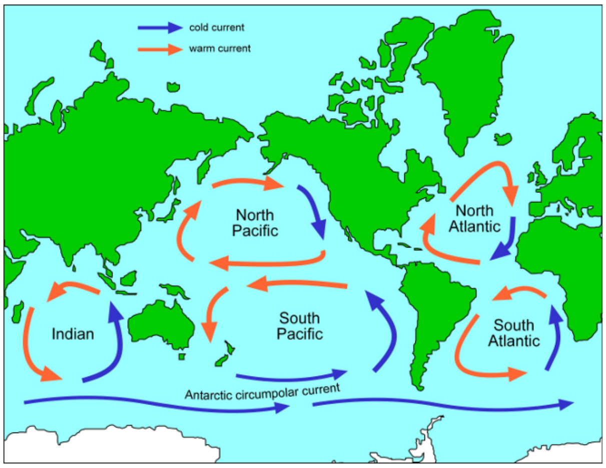

Figure 1 showing the five main gyres that act as garbage heaps in the ocean

Where are they within the solent?

Research by Anthony Gallagher et al (2016) looked into the spread on microplastics through the water column within the Solent esturing column. This research found that the most common plastic were the fiberous microplastics, closelt followed by the microplastics found in cosmetics. The low numbers of irregularly shaped microplastics suggested that there are new pieces of plastic breaking down within the complex. The river Itchen seemed to have the largest amount of microplastics compared with the Hamber and Test; this could be caused by the plastic industry based complex that is found on the river. The River Hamble may have been expected to have a higher amount due to the amount of boats moored in the estuary. This would have increased the amounts of fibres from ropes (Andrady 2011) but it seemed not to be the case due to its more rural setting. This study showed that there were higher levels where there was a higher population. Due to the highest concentration of microplastics being cosmetic beads and fibres, it is most likely that these are coming from wastewater treatment plants located on all three rivers and Southampton water.

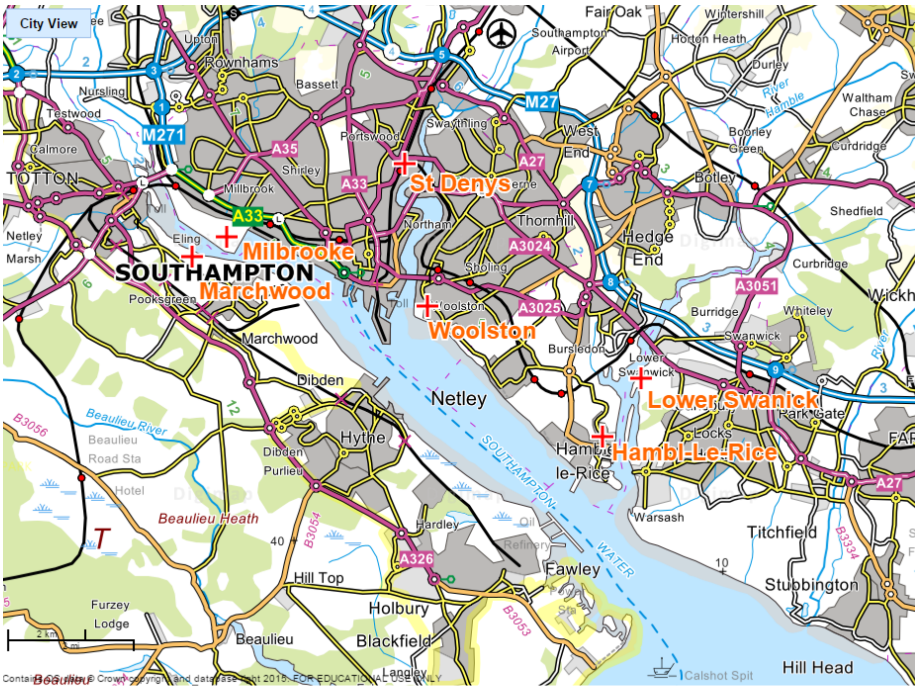

Figure 2 adapted from Edina Digimap showing locations of waste water treatment works as +.

Figure 3 taken from Browne et al (2011) supports the work done by Gallagher. In the image below it is clear that the Oceans around England have a high amount of microplastics compared with other locations (A). We can also see that there is am much higher amount of microplastics found in areas near by a waste disposal site compared with a similar site having no waste disposal (C). The large amounts of microplastics in the Sloent could be due to the high population around it's coast. This is evident in image B. The amount of microplastics rises with the population in the area.

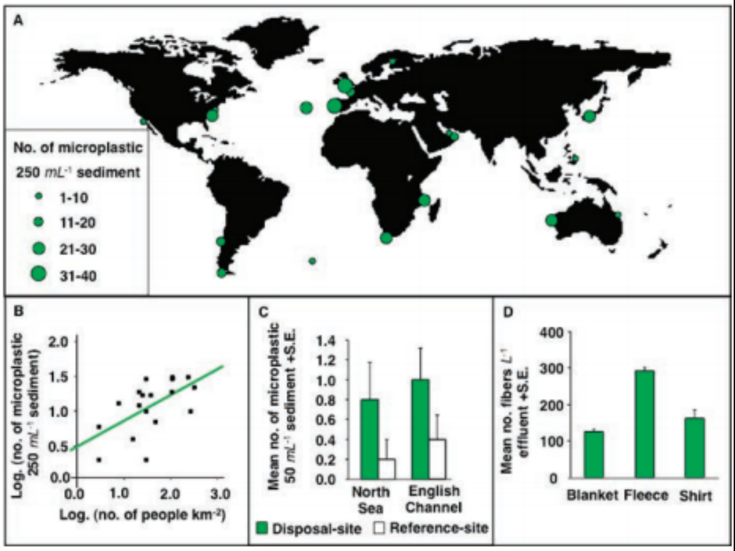

Figure 3 taken from Browne (2011). (A) Global extent of microplastic in sediments from 18 sandy shores and identified as plastic by Fourier transform infrared spectrometry. The size of filled-circles represents number of microplastic particles found. (B) Relationship between population-density and number of microplastic particles in sediment from sandy beaches. (C) Number of particles of microplastic in sediments from sewage disposal-sites and reference-sites attwo locations in U.K. (D) Number of polystester fibers discharged into wastewater from using washing-machines with blankets, fleeces, and shirts (all polyester).

What problems do they cause and how do they cause them

Microplastics are the cause of two issues.

1) They are ingested by small marine organisms such as molouscs, small fish and sea birds. This can be accidental ingestion or intentional. Small fish and birds have been found to eat micro plastics that look similar to their regular prey. Once this occurs, the plastics are in the food chain resulting in larger animals ingesting large amounts of plastic which can result in their death. The effects of microplastic ingestion has been highly researched and includes things such as: internal and external wounds, blocking of the digestive system resulting in starvation, filling of the stomach leaving less room for nutritious food leading to reduced health and plastic absorption of toxic chemicals in the stomach (Gregory 1978, 1991, Laist 1997, Mato et al 2001).
2) Microplastics act as a sponge for pollutants found in the oceans. The pollutants are absorbed and transported across the world in the particles that are difficult to degrade. These chemicals can cause pollution and algal bloom in some areas, this can cause the demise of other species.

Effects of Microplastics on Species and Habitats Around the World

IT has been shown that microplastics move through the smallest of trophic levels from Artemia (a species of brine shrimp) to Stickleback larvae. Experiments by Katzenberger and Thorpe (2015) show that there is more consumption of microplastics by the fish larvae in waters with a higher concentration of plastics. It was also shown that when exposed to Artemia with a higher plastic contamination, the fish were then found to have a higher contamination. However, these results did not show any alterations in weight or length of the fish over a 7 day period. It was shown that bisphenol A (BPA), a chemical used in the production of plastics, has an influence on the uptake of plastics by. Fish exposed to plastics with the increased BPA showed a reduction in consumed plastics suggesting BPA reduces the eating habits of animals. It is chemicals like ABP that are transported on microplastics across the world. Although the microplastics showed to have little direct effect in these experiments, the chemicals that they could carry may influence species a great deal.

The consumption of microplastics by small species such as mussels, oysters and sea worms is now taken as fact. The fact that they are ingested is no longer questioned but weather they are causing significant harm to the species is still being researched. Sussarellu et al (2016) researched the effect of microplastic consumption on the Pacific Oyster. It was found that the oysters exposed to microplastics had a significant reduction in the production of reproductive cells. It was also found that their diameter was reduced by 5% and their sperm speed reduced by 23%. It was concluded that microplastics caused drastic reductions in feeding and reproduction and had significant impacts on offspring.

There has been research into the amount of plastic found in sea birds off the coast of British Columbia (Blight and Burger 1997). 75% of 11 species examined has plastic particles contained in their gut. These species included birds that feed on the surface of the ocean and also birds that dive below the surface to catch prey. The Birds that dive for their prey showed no traces of plastics in their gut suggesting it is not passed through the food chain. Alternately, the birds that are likely to feed on floating surface material had consumed a lot more plastic.

Eriksson and Burton (2003) produced a report showing the amount of small plastic particles in fur seals on the Macquaire Island. The types of particles found in the seals' faeces lead researchers to hypothesise that fish had consumed the plastics and then the seals had ingested the plastics through their normal process of feeding.

There has been evidence of plastic being washed up onto shores of beaches. The aesthetic issues of microplastics are small due to them being too small to see on many beaches. The main plastics causing aesthetic issues in habitats are meso and macro plastics. These plastics litter beaches like the ones shown in figure 4. They may also harm wildlife such as birds living on the shoreline. Birds may ingest the smallest pieces of plastic mistaking them for food. The plastics may also be sharp, meaning some animals can harm themselves by scratches and cuts. Microplastics washed up on beaches are then free for small birds to ingest. If they are washed up onto mud flats, birds such as curlews and oystercatchers.

Figure 4 Taken from Thomson (2015). Image of a European beach crowded with micro, meso and macro plastics.

Are Microplastics a Problem for the Solent?

Although there is no research conducted specifically on species within the Solent, many other research papers have looked at different topics that look at species similar to those found in the Solent region.

Artemia used in the experiments by Katzenberger and Thorpe (2015) are not found in open sea. They are found in saline lakes of America and are not common in the Solent. Alternatively, the sticklebacks used in their experiments are common around the United Kingdom. They feed on small creatures such as insects, crustaceans and fish larvae. Similar to the Artemia, these species are likely to be consuming plastic particles depending on the concentration within the Solent.

Pacific oysters used in the experiments by Sussarellu et al (2016) proved that microplastics had significant impacts on reproduction and food consumption. These oysters are now native to many places across the globe including Europe. This means that the oysters in the Solent could suffer from very similar effects shown by the Pacific Oysters in the experiments conducted.

Many of the birds that occupy harbours around the Solent feed on small insects and fish. The majority graze at intertidal zones and low water. This could suggest that these birds are likely to be picking up small fragments of plastic floating on the water like those that were examined off the coast of British Columbia. Some birds, such as the Little Turn, often plunge dive for food suggesting they may be less likely to directly consume plastics but they may ingest it through the food chain (Blight and Burger 1997).

Harbour Seals' are common marine animals around the Solent coast. Bravo et al (2013) conducted research on harbour seals' in the Netherlands. It was found that 11% of the 107 seals sampled contained plastics within their stomachs. The most effected seals were the youngest, aged up to 3 years old. In this study, the smallest size of plastics (0.12-0.3mm) may not have been detected. This may cause the result to be much lower than it should be. Out of 125 faeces samples, there were no traces of plastics. Again, this may be due to the method not picking out some of the smallest pieces. The research by Eriksson and Burton (2003) suggested that seals consume microplastics through the food chain. Although the seals in this survey have slight differences, they share a similar diet of small fish, molluscs and squid. This could prove that the seals local to the Solent may also suffer from the same consumption of plastics as those in the Macquaire Island. These two research projects may cause some concern for the harbour seal species living in the Solent as there was evidence for microplastic ingestion in both locations

Ogata et. al (2009) conducted research into persistent organic pollutants found on microplastics in 17 countries across the world. It was found that Western Europe was one of the countries with the highest polychlorinated biphenyls (PCBs). This is a persistent organic pollutant found in some coolants. It has now been banned in the many countries. It was produced in south Wales and contamination still affects the oceans around south England and Wales (Levit 2011). PCB's are hydrophobic causing them to be absorbed into microplastics (Mato et al 2001).

The percentage of microplastics that are inhabited by species has been studied with the increase of altitude across the globe. It was found that the amount of plastics increases in the southern Hemisphere with latitude but in the Northern hemisphere amount increase with latitude up to 60^{o}N where it reduces again to 80^{o}N (Figure 5). This may show that the Solent could have a large problem with the amount of microplastics as Britain lies between 50^{o}N and 60^{o}N. The percentage of these plastics that were colonised by foreign species reduced with latitude showing almost 0% of the sampled plastics were colonized above 50^{o}N. This may suggest that the Solent has a bigger problem related to the consumption of microplastics due to the volume rather than the invasion of species caused by the particles.

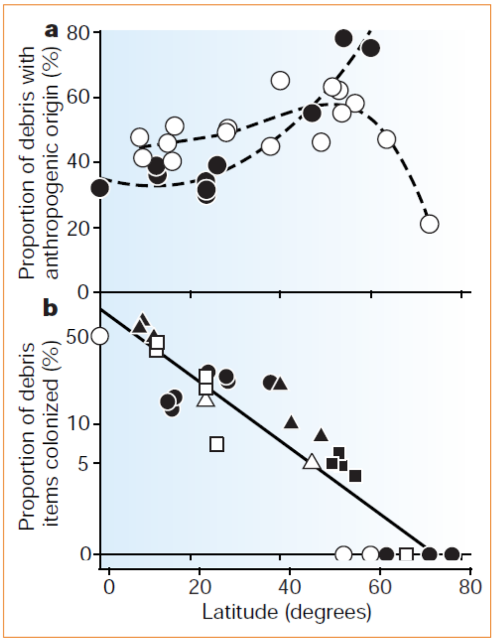

Figure 5 Adapted from Barnes (2002). Colonization of man-made and natural debris by marine organisms at different latitudes. **a,** Proportion of man-made debris found offshore at 30 remote islands (Fig. 1); debris is classed as either anthropogenic (mainly plastic) or natural (mostly wood, but not lumber); n<200 for each point. Open symbols, islands in the Northern Hemisphere; filled symbols, islands in the Southern Hemisphere. **b,** Variation with latitude, hemisphere and remoteness of island shorelines in the proportion of marine debris of each type that was colonized by fauna. Symbols represent the distance of each island from the continental mainland: circles, hundreds of kilometres; triangles, tens of kilometres; squares, less than 10 km. Fitted regression line has associated r 2472.7, and significance by ANOVA: F485, P 0.001.

Further Research

This research shows possibilities for the Solent region to have strong concerns about microplastics and how they affect the habitats and species. The work done by Anthony Gallager et al (2016) has proven that the amounts of microplastics within the Solent are significant. It has also shown what types of plastics are in the Solent and where they are coming from. Although this is a big step into looking at the damage caused by these small fragments, it is yet unknown what specific problems they cause to our local species and habitats. Specific species within the Solent should be looked at through experiments such as those by Katzenberger and Thorpe (2015) or through looking at animals in their environment like the work done on seal faeces on the Macquaire Island. With this research, a better conclusion can be made to whether microplastics are harming the Solent's species. With the amount of debris doubling from 1994 to 1998 around the coastline of the United Kingdom (Mínguez-Mosquera and Hornero-Méndez 1993) and much more since then, there is a definite need for a better understanding of contamination in specific costal environments.

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