Agenda - Climate Change, Environment and Rural Affairs Committee

Meeting Venue:	For further information contact:
Committee Room 3 - Senedd	**Marc Wyn Jones**
Meeting date: 10 October 2018	Committee Clerk
Meeting time: 09.30	0300 200 6363
	SeneddCCERA@assembly.wales

1 Introductions, apologies, substitutions and declarations of interest

2 Inquiry into the impact of microplastic pollution in Welsh waterways: evidence session one

(09.30 - 10.30) (Pages 1 - 23)

Professor Steve Ormerod, Professor of Ecology / Co-Director Water Research Institute, School of Biosciences - Cardiff University

Fredric Windsor, PhD Student, Organisms and Environment Research Division, School of Biosciences - Cardiff University

Attached Documents:

Research Brief

Paper - Steve Ormerod

Paper - Fredric Windsor

Break (10.30 - 10.40)

3 Inquiry into the impact of microplastic pollution in Welsh waterways: evidence session two

(10.40 - 11.40) (Pages 24 - 41)

Gill Bell, Head of Conservation Wales - Marine Conservation Society

Julian Kirby, Lead Plastics-Free Campaigner - Friends of the Earth

Attached Documents:

Paper - Marine Conservation Society

Friends of the Earth

4 Paper(s) to note

4.1 Correspondence from the Cabinet Secretary for Finance to the Temporary Chair of Finance Committee - draft Budget 2019-20

(Pages 42 - 43)

Attached Documents:

Letter from the Cabinet Secretary for Finance

5 Motion under Standing Order 17.42 to resolve to exclude the public from the meeting for item 6

6 Inquiry into the impact of microplastic pollution in Welsh waterways: consideration of oral evidence received under items two and three

(11.40 - 12.00)

7 Discussion of forward work programme

(12.00 - 12.10) (Pages 44 - 45)

Attached Documents:

Paper

By virtue of paragraph(s) vi of Standing Order 17.42

Agenda Item 2

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Microplastic ingestion by riverine macroinvertebrates

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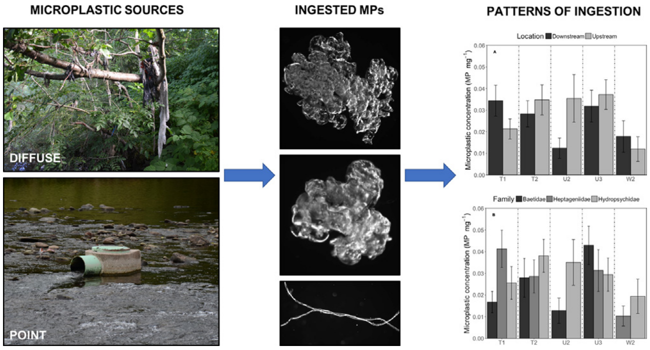
HIGHLIGHTS

- Microplastic ingestion by riverine macroinvertebrates was assessed over South Wales.
- Microplastics were identified in approximately 50% of macroinvertebrate samples.
- Ingestion of microplastics was observed in all taxa, across all sites.
- No difference in microplastic burden was observed downstream of sewage treatment works.

GRAPHICAL ABSTRACT



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ABSTRACT

Although microplastics are a recognised pollutant in marine environments, less attention has been directed towards freshwater ecosystems despite their greater proximity to possible plastic sources. Here, we quantify the presence of microplastic particles (MPs) in river organisms upstream and downstream of five UK Wastewater Treatment Works (WwTWs). MPs were identified in approximately 50% of macroinvertebrate samples collected (Baetidae, Heptageniidae and Hydropsychidae) at concentrations up to 0.14 MP mg tissue^{-1} and they occurred at all sites. MP abundance was associated with macroinvertebrate biomass and taxonomic family, but MPs occurred independently of feeding guild and biological traits such as habitat affinity and ecological niche. There was no increase in plastic ingestion downstream of WwTW discharges averaged across sites, but MP abundance in macroinvertebrates marginally increased where effluent discharges contributed more to total runoff and declined with increasing river discharge. The ubiquity of microplastics within macroinvertebrates in this case study reveals a potential risk from MPs entering riverine food webs through at least two pathways, involving detritivory and filter-feeding, and we recommend closer attention to freshwater ecosystems in future research.

1. Introduction

Microplastics (particles <5 mm) constitute a major potential threat to global aquatic ecosystems (Avio et al., 2017), with a widespread distribution (Barnes et al., 2009), and a wealth of literature demonstrating ecological effects (e.g. Wright et al., 2013a). Laboratory and field assessments show that the ingestion and translocation of microplastic particles (MPs) can affect aquatic organisms (Wright et al., 2013b) including zooplankton (Cole et al., 2013), invertebrates (von Moos et al., 2012), fish (Lusher et al., 2013) and birds (Provencher et al., 2014). Overwhelmingly, however, research has focused on marine ecosystems and organisms rather than on the freshwater ecosystems that are linked more closely to terrestrial microplastic sources (see Wagner et al., 2014; Eerkes-Medrano et al., 2015; Wagner and Lambert, 2017).

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Significant sources of MP pollution include plastic textile fibres (Browne et al., 2011) and degrading macroplastics whose origins are concentrated on land (Jambeck et al., 2015). From there, a major component of the flux of terrestrially derived plastic particles into marine environments is likely to arise from Wastewater Treatment Works (WwTWs) or associated storm overflow systems that discharge into rivers (Mani et al., 2015).

Studies assessing plastic contaminants in freshwater environments have focused on organisms occupying the higher trophic levels of food webs, such as fish (e.g. Foekema et al., 2013; Sanchez et al., 2014) but a few recent studies have identified the ingestion of microplastics by freshwater invertebrates, including Tubificid worms, *Gammarus pulex* and *Hyalella azteca* (Hurley et al., 2017; Weber et al., 2018; Redondo-Hasselerharm et al., 2018). Controlled exposures of freshwater invertebrates (*G. pulex*, *H. Azteca*, *Asellus aquaticus*, *Sphaerium corneum* and *Tubifex* spp.) to MPs have exhibited no overt toxicity for environmentally relevant concentrations (Redondo-Hasselerharm et al., 2018) and a meta-analysis of published studies indicates relatively few negative impacts of microplastic exposure in fish and invertebrates (Foley et al., 2018). Previous studies, however, have focused predominantly on broad scale or (e.g. growth, reproduction and feeding) lethal endpoints (survival and mortality) or have been conducted for short exposure durations (28 days). Thus, chronic effects across a range of more subtle biological endpoints may still present a health risk to invertebrates. A more comprehensive understanding on the ingestion of microplastics by riverine macroinvertebrates is needed given their frequent position as primary consumers supporting riverine food webs and their potential use for determining the origins and entry points of MPs in freshwater food webs.

Microplastic concentration and bioavailability in rivers is likely to be affected by factors that include upstream land-use, urban runoff, relative volumes of discharged effluent from point wastewater sources and local hydraulics that determine entrainment or deposition (Nizzetto et al., 2016; Besseling et al., 2017; Nel et al., 2018). Recent studies have indicated the existence of high concentrations of microplastics in river sediments (Hurley et al., 2018), but they have also shown the significant removal of MPs from river sediments in response to floods. These physical factors influencing the occurrence and abundance of microplastics within the environment will determine the likelihood of ingestion by aquatic organisms, particularly those whose feeding traits involve either ingesting organic particles from the benthos or by filtering material contained in the water column (e.g. Wright et al., 2013b). Other biotic factors such as organism size, mouthpart morphology and gut recharge rate may also influence both MP ingestion and retention. Thus, the presence of microplastics within the biotic components of freshwater food webs is likely to be related to a combination of biotic and abiotic factors.

Once ingested, microplastics can affect aquatic organisms in various ways (Wright et al., 2013a; Scherer et al., 2017). The presence of microplastics in the digestive tract, for example, has the potential to inhibit nutrient absorption and reduce; (i) consumption of resources, (ii) growth, (iii) reproduction and (iv) survival (Lee et al., 2013; Wright et al., 2013a; Au et al., 2015; Cole et al., 2015; Lei et al., 2018). These biological effects have been reported for marine polychaete worms and bivalves, but only for exposure concentrations far exceeding those found in natural environments (Lenz et al., 2016). MPs can also harbour polychlorinated biphenyls (PCBs) and other xenobiotic pollutants that adsorb onto their surface, thereby providing routes for secondary toxicity (Besseling et al., 2013; Ziccardi et al., 2016) and potentiating the effects of toxic chemicals (Syberg et al., 2017). All of these effects indicate both potential MP risks to individual organisms, and also potential emergent effects on ecosystem function that require investigation (Thompson et al., 2009).

This paper reports on microplastic ingestion by riverine macroinvertebrates around five Wastewater Treatment Works (WwTWs) along the Rivers Taff, Usk and Wye in South Wales (UK). In particular, we: (i) assessed the presence of microplastics within the bodies of macroinvertebrates from two contrasting feeding guilds (benthic grazers/detritivores vs filter feeders); (ii) determined whether microplastics are ingested and/or excreted; and (iii) explored the influences on microplastic ingestion across macroinvertebrate taxa.

2. Materials and methods

2.1. Sample sites

The South Wales valleys once held some of the most polluted watercourses in Europe, with over 70% of rivers classed as grossly polluted. Despite major recovery, there is continued contamination near to urban centres from both macronutrients and complex organic substances (Vaughan and Ormerod, 2012; Morrissey et al., 2013a, 2013b). The Taff catchment is representative of highly urbanised river systems within South Wales. The adjacent Usk and Wye systems drain more rural catchments that were never grossly polluted, but still maintain some urban drainage. Across these catchments five WwTWs were selected along a gradient of effluent input, river discharges and potential MP exposure (Fig. 1; Table S1). At each location, macroinvertebrates were collected (June–July 2016) from two 20 m reaches respectively within 200–1000 m upstream and downstream of WwTW outflows. Upstream sample locations were all a minimum of 5 km downstream of proximal upstream point-sources of pollution (e.g. WwTW discharges and industrial outflows).

2.2. Environmental characterisation

Stream chemistry at each site was assessed during the macroinvertebrate collection period through spot measurements of pH, electrical conductivity (EC), total dissolved solids (TDS) and water temperature (HI-9813-5; Hannah Instruments, UK). River discharge was calculated from gauging stations within 2 km of each sample site and collated as mean daily discharge (m^3 day^{-1}) using 5-yr data from Natural Resources Wales (NRW), the State regulatory organisation. Consented effluent discharges for WwTWs were derived from NRW secondary data (Licence No. ATI-10578a) and dry weather flow (m^3 day^{-1}) was collated. The ratio of daily WwTW effluent discharge to river discharge was calculated to assess the relative dilution of these effluent inputs and to understand the potential effects of point source effluent dilution on microplastic interactions with freshwater organisms.

Geographical Information Systems (GISs) were used to derive land use cover upstream of sites using ArcGIS software (version 10.2.2). Phase 1 JNCC habitat classification data for the UK (JNNC, 2010), coupled with flow network data from the NERC Centre for Ecology and Hydrology (CEH) (Licence no. 16122014), were processed using the Spatial Tools for the Analysis of River Systems (STARS) package (Peterson and Ver Hoef, 2014). This package allowed for calculation of cumulative area of land cover within contributing sub-catchments upstream of sample sites (see Peterson et al., 2006).

2.3. Macroinvertebrate sampling

We investigated three abundant macroinvertebrate families from two orders (Ephemeroptera and Trichoptera): Heptageniidae, Baetidae and Hydropsychidae. Heptageniidae and Baetidae mayflies feed predominantly upon benthic algae and fine amorphous particles within river systems, whereas hydropsychid caddisflies are generalist filter-feeders (Tachet et al., 2002). In each sample reach, 18 individuals of each taxon were collected using a validated method of intensive kick sampling and hand-searching (Bradley and Ormerod, 2002). The exceptions to this were for one sample site on the Wye (W2), and a site on the Usk (U2), where a limited abundance of Baetidae and Heptageniidae, respectively, precluded these taxa from microplastic analyses. Macroinvertebrate individuals were identified in the field and individuals of

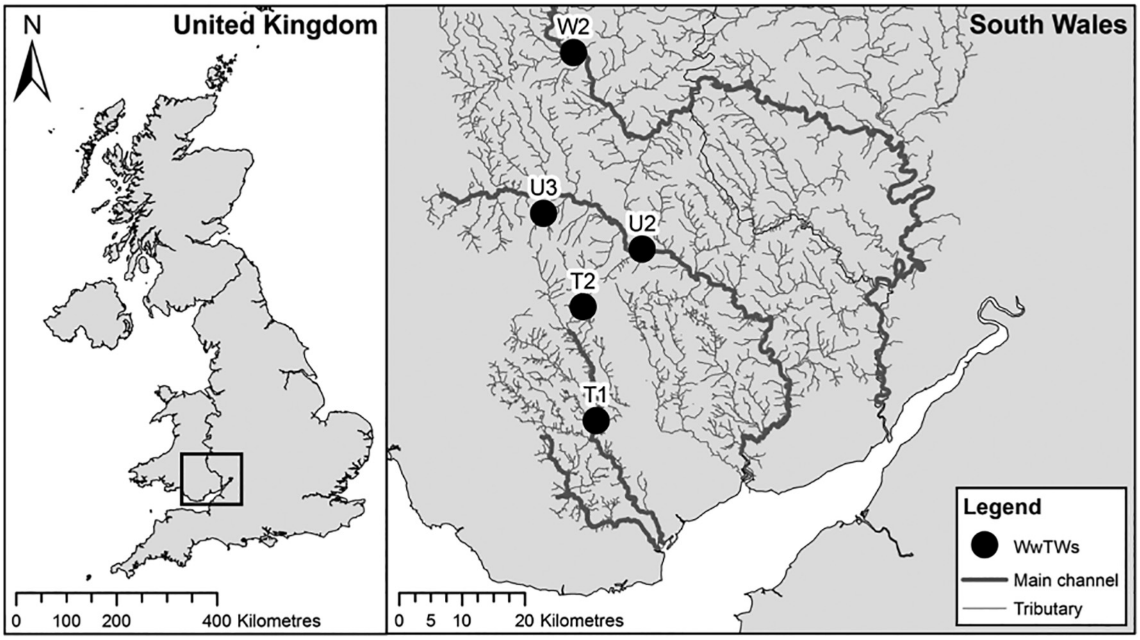


Fig. 1. Location of sample sites across South Wales. Taff (T1, T2), Usk (U2, U3) and Wye (W2) river catchments. Site labels reflect a coding scheme adopted for a wider distribution of sample sites across South Wales.

each taxon were divided into two halves that were either (i) immediately fixed in 70% ethanol to prevented gut content excretion or (ii) placed into glass vials (200 ml), filled with river water. Unpreserved samples were transported to the laboratory at stream temperature (8–14 °C), where they were kept at ~4 °C for 24 h to allow gut clearance (Brooke et al., 1996) before also being fixed in 70% ethanol.

For both sets of samples (preserved and gut-cleared), the biomass (mg dry weight) of each individual macroinvertebrate was determined from measurements of head-capsule width and body length using length-biomass conversion equations (e.g. Towers et al., 1994). Three individuals of each macroinvertebrate family collected were then pooled together to provide composite samples for microplastic analyses. Henceforth, composite samples are simply referred to as 'samples'.

2.4. Microplastic processing

The processing of macroinvertebrate samples followed a similar methodology to that detailed in Avio et al. (2015). Briefly, composite macroinvertebrate samples were initially rinsed with filtered deionised water to remove any exterior MPs. Samples were then homogenised with a mortar and pestle and subsequently mixed with 50 ml of hypersaline solution (1.2 g cm^{-3}). The solutions were filtered and decanted into 50 mm petri dishes containing 20 ml of 15% hydrogen peroxide (H_2O_2) solution where they were left at 25 °C for 48 h to allow pigment and chitin degradation before further microscopic analysis. As microplastic contamination from external sources (e.g. solutions used for the animal processing and worker clothing) provide a major potential source of error (Foekema et al., 2013), all deionised water and hypersaline solutions were pre-filtered (0.45 μm cellulose filter) and all pre-processing was completed in a laminar flow cabinet. Cotton laboratory coats and nitrile gloves were utilised at every stage of processing to further prevent contamination. Finally, an assessment of exogenous contamination present as a result of processing procedures was completed using control blanks prior to analysis. In all control assessments a low number of particles were observed and particles similar to those identified within controls (predominantly white cotton fibres) were eliminated from further analyses.

2.5. Microscopy and spectroscopy

We used a tandem microscopy technique to identify and count microplastics in processed macroinvertebrate samples. Light-microscopy (Leica EZ4, Wetzlar, Germany) was used initially to scan each sample and identify suspected microplastics (0.5–5 mm). Visual analyses were completed following Löder and Gerdts (2015), who demonstrated that for particles over 0.5 mm, visual analyses were suitable for identification. Samples were then analysed using light microscopy, bright- and dark-field spectroscopy (Olympus BX40, Tokyo, Japan) to confirm microplastic identification (Fig. 2) and distinguish plastic from natural particles based on physical and structural features (e.g. presence of cell structures, homogenous structure and uniform reflectance). The spectra obtained were compared against reference microplastic material collected from a range of sources and criteria were used to identify plastic particles (see Fig. S1 and Table S2). Finally, the total abundance of MPs within each sample was determined.

2.6. Statistical analysis

The likelihood of occurrence (binomial, 0–1), abundance (count, 0–6 MPs) and concentration (MP mg tissue^{-1}, 0–0.14) of microplastics within composite macroinvertebrate samples was investigated using 'R' (version 3.2.3) (R Core Team, 2015). Prior to specific analysis a series of exploratory statistical assessments analysed data structure and guided further statistical methodology (as detailed in Zuur et al., 2010) depending on normality, heteroscedasticity and outliers. Generalised Linear Models (GLMs) and Generalised Linear Mixed Models (GLMMs), the latter fitted using the package 'lme4' (Bates et al., 2015), were used to account for negatively skewed data (Bolker et al., 2009; Zuur et al., 2009). Binomial distribution models were used to assess the presence of plastic within samples, with log and square-root transformed abundance and concentration data analysed using Gaussian distributions. Where appropriate, random effects were included in models to control for site-associated variation, location in relation to WwTW outflows and sample type (gut contents present or absent). Model validation, following the approaches of Zuur et al. (2007), and Thomas et al. (2015), was conducted to assess model validity and

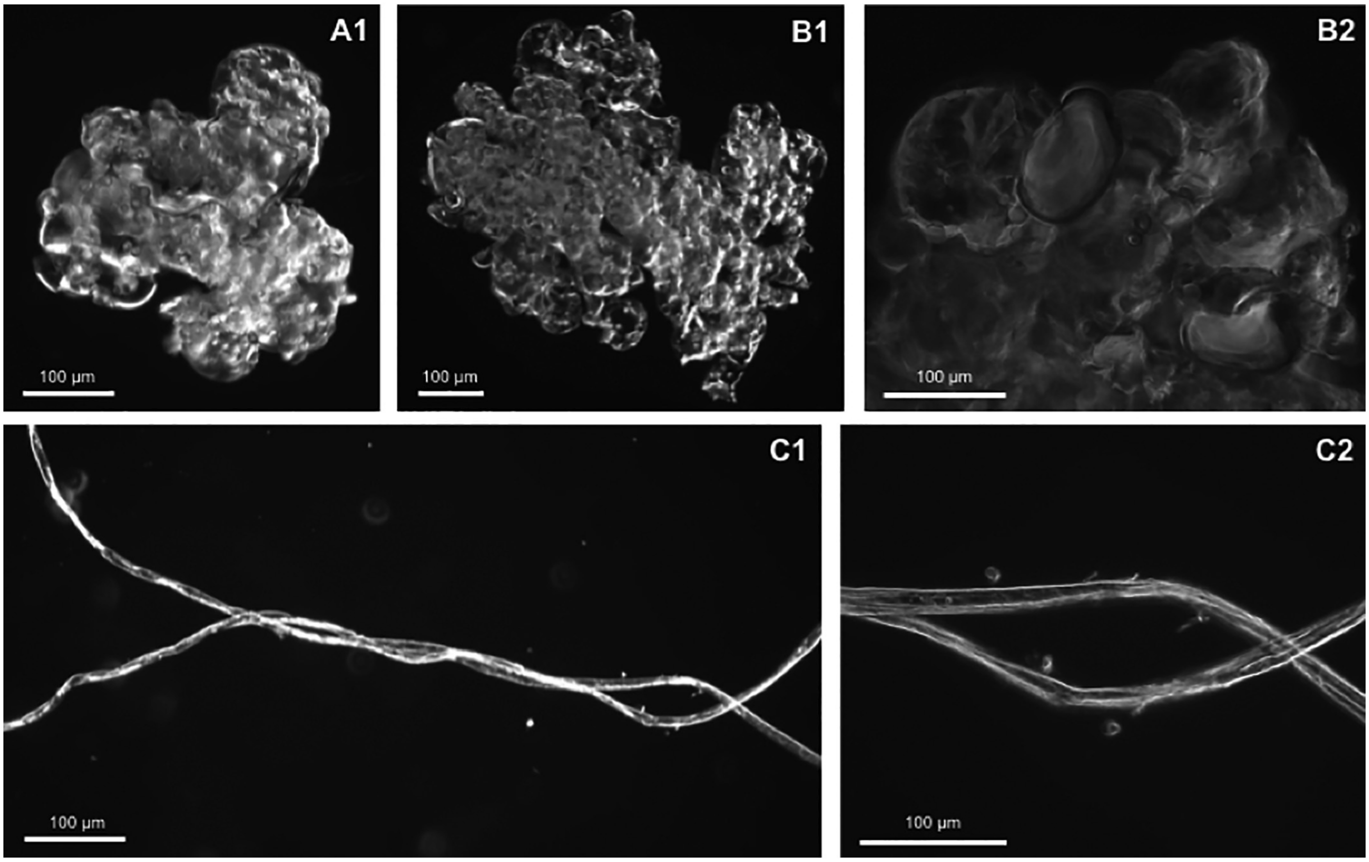


Fig. 2. Images from microplastic dark-field spectroscopic analyses at various magnifications. A and B = MPs; C = Microplastic fibre. Images captured using an Olympus BX40 microscope (Tokyo, Japan).

accuracy. The residual normality was assessed using QQ plots, homogeneity of variance was determined by plotting residuals against fitted values, and influential observations were investigated using Cook's leverage distances.

3. Results

3.1. Site effects on microplastics in macroinvertebrates

Microplastics were present in invertebrate samples at all sites, both upstream and downstream of WwTWs (Fig. 3). The site-averaged likelihood of microplastic presence across samples was significant, yet highly variable across sites ($R^2c = 0.15$, $F_{4,150} = 3.60$, $p = 0.007$) largely because of large pairwise differences and lower occurrence at W2 (Fig. 4). Microplastic abundance within macroinvertebrates varied more systematically, both overall and in pairwise comparisons ($R^2c = 0.16$, $F_{4,149} = 3.66$, $p = 0.002$).

Both MP presence ($R^2c = 0.12$. $F_{1,152} = 10.821$, $p = 0.001$) and abundance varied with river discharge (i.e. flow volume) across sites ($R^2c = 0.15$, $F_{1,151} = 6.15$, $p = 0.024$), with the abundance of ingested microplastics decreasing with increasing river discharge (-0.015 ± 0.006 MPs $m^3\ s^{-1}$). Yet again, models only explained a small proportion of variation in the data.

Land use upstream of the sample location did not appear to have an effect on the likelihood of MP presence or abundance ($p > 0.05$, in all cases), nor did it increase explanatory power in GLMMs. However, the ratio of effluent to river discharge downstream of WwTW outflows associated with increased MP abundance ($R^2c = 0.19$, $F_{2,85} = 16.42$, $p < 0.0001$).

3.2. Gut clearance effects

Microplastic presence was significantly reduced in macroinvertebrates when gut contents were evacuated (-0.97 ± 0.35, $z = -2.80$, $p = 0.005$) compared with non-evacuated samples ($R^2c = 0.14$, $F_{1,149} = 8.05$, $p = 0.004$). Similarly, the relative abundance of microplastics was significantly reduced where macroinvertebrates had been allowed to evacuate gut contents naturally ($R^2c = 0.14$, $F_{1,149} = 12.90$, $p < 0.0001$; $t = -3.67$, $p < 0.0001$; Fig. 5).

3.3. Taxonomic and guild effects

Taxonomic identity, macroinvertebrate biomass and interactions between the two, explained significant variations in microplastic abundance across macroinvertebrate samples ($R^2c = 0.35$, $F_{2,147} = 66.73$, $p < 0.0001$). Pairwise differences between taxa were significant ($z_{2,147} = 15.92$, $p = 0.001$), with baetid mayflies containing a lower abundance of microplastics than either the Heptageniidae ($F_{2,147} = 2.74$, $p = 0.006$) or Hydropsychidae ($F_{2,147} = 2.33$, $p = 0.019$). Microplastic abundance was also positively related to biomass ($F_{1,147} = 4.35$, $p < 0.0001$). Biomass relationships differed among macroinvertebrate taxa ($F = 4.12$, $p = 0.017$), such that the Heptageniidae contained a greater abundance of MPs mg^{-1}, in comparison to both Baetidae and Hydropsychidae, due to the greater mass of individuals within this taxon.

Macroinvertebrate feeding guild did not influence the presence ($R^2c = 0.15$, $F_{1,151} = 2.13$, $p = 0.15$) or abundance of MPs within macroinvertebrate samples ($R^2c = 0.08$, $F_{1,151} = 0.621$, $p = 0.535$), implying that grazer/detrivores and filter-feeders both ingest microplastic.

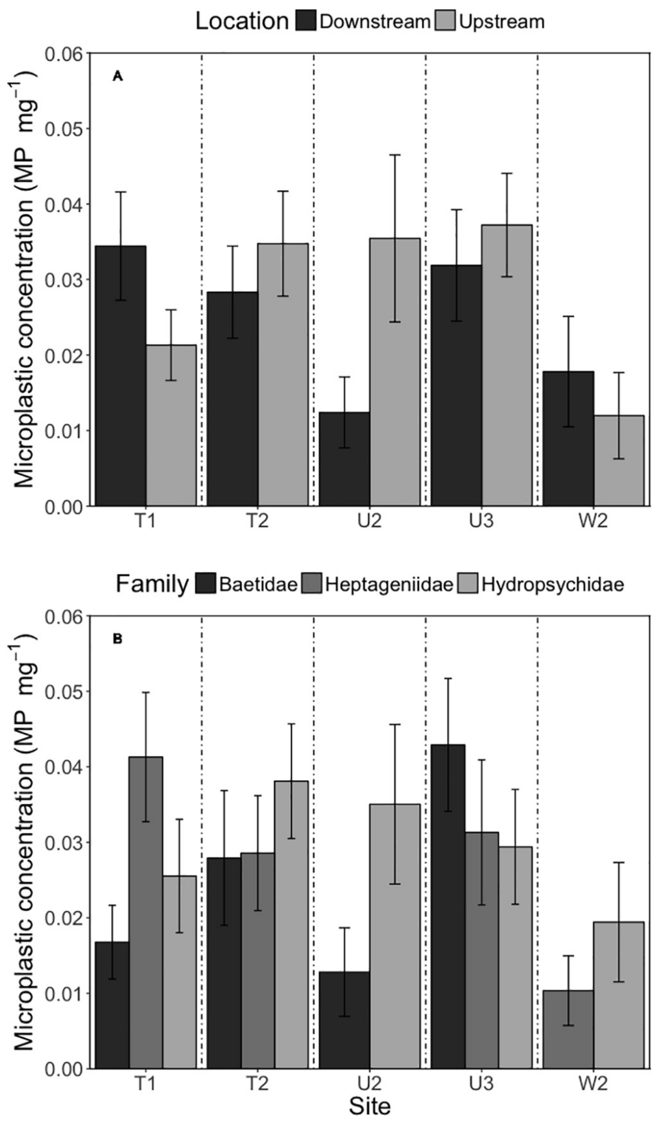
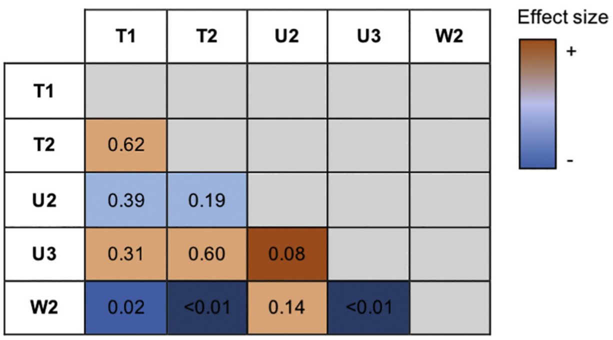


Fig. 3. Microplastic concentrations (MP mg^{-1}) for macroinvertebrate families across sample sites. Taff (T1, T2), Usk (U2, U3) and Wye (W2) river catchments. A = comparisons between upstream and downstream sample sites at each location; B = comparisons between taxa collected at each site (pooled based on absence of significant difference in A). Bars indicate mean values and error bars are ±1 standard error.



	T1	T2	U2	U3	W2
T1					
T2	0.62				
U2	0.39	0.19			
U3	0.31	0.60	0.08		
W2	0.02	<0.01	0.14	<0.01	

Fig. 4. Pairwise comparisons of microplastic presence within macroinvertebrates across sample sites. Comparisons of microplastic presence probabilities in invertebrates from GLMM analysis. Effect sizes and p values were derived post-hoc using pairwise Wald-tests. p-Values are reported within the corresponding cells. Colour indicates the magnitude and direction of the effect size, calculated based on row-column comparisons.

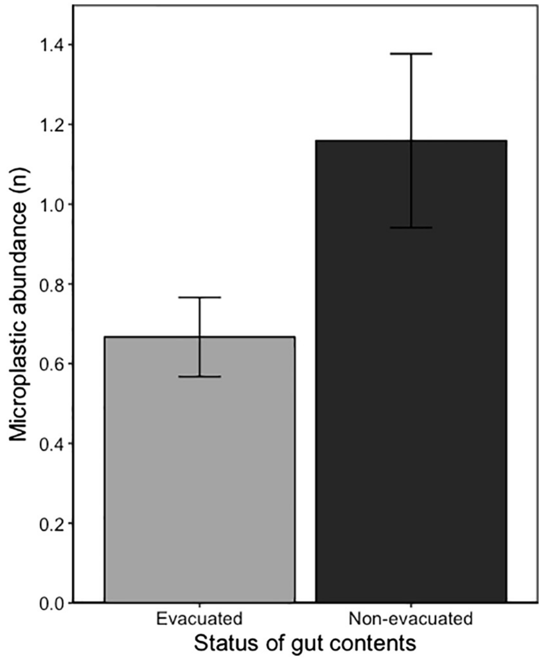


Fig. 5. Microplastic abundance in macroinvertebrate samples with evacuated and non-evacuated gut contents. Substantial gut clearance was assumed after macroinvertebrates have been kept for 24 h in 4 °C stream water; after Brooke et al. (1996). Bars indicate mean values and error bars are ±1 standard error.

4. Discussion

Microplastics occurred in macroinvertebrates at all sites in the study, indicative of the high levels of litter and plastic pollution within these catchments and consistent with near-urban river systems more widely (Jambeck et al., 2015; Duis and Coors, 2016). Although there is a recognised caveat in that visual analysis can overestimate microplastic abundance, the data are unequivocal in indicating that plastic particles are entering freshwater food webs from basal levels. This further highlights the potential risks of microplastic pollution to freshwater organisms and ecosystems. In the discussion that follows, we address environmental and biological factors affecting MP entry into food webs, speculate about the possible consequences, and identify important gaps in for further research on freshwater ecosystems.

Flow dynamics in rivers are likely to affect the interaction between MPs and freshwater organisms, and one of the most interesting aspects of our data was the lack of a clear association between putative sources in WwTWs and MP occurrence in macroinvertebrates. One possible explanation is that flow dilution could affect microplastic bioavailability. This is consistent with patterns in other xenobiotic pollutants where lower dilution can increase contamination risk and the likelihood of bioaccumulation (Dris et al., 2015a). In these South Wales catchments, dilution – specifically the high ratio of river flow to effluent discharge – might have obscured WwTWs as pollution sources (see Lechner and Ramler, 2015). Such dilution effects might be compounded where emissions of microplastics from WwTW outflows relative to background sources are small per unit water volume. Murphy et al. (2016), for example, demonstrated MP removal rates of over 98% at a WwTWs (650,000 population equivalent) resulting in a relatively low emission concentrations (0.25 MP L^{-1}). Even at such low concentrations, however, absolute emission rates per day can still reach 65 million MP particles (Murphy et al., 2016). An alternative explanation for the patterns in our data, therefore, is that other MP sources could mask local WwWT effects on ingestion of plastics by freshwater organisms. Macroplastics can enter river systems diffusely from litter such food wrappers, plastic bottles and plastic cutlery (Dris et al., 2015b), and provide a diffuse source of microplastics. Potentially more important are a range of direct microplastic sources such as abraded road paints, textiles, and vehicle tyres that occur diffusely across river catchment ecosystems. For example, road run-off or combined sewer overflows that by-pass wastewater treatment may contribute to microplastics in the environment. Until such sources or flowpaths are quantified and linked to specific biological effects, the optimum strategies for remediating aquatic microplastic pollution will be difficult to identify (Siegfried et al., 2017).

Turning to the biological factors that might affect the occurrence of microplastics in organisms, microplastic ingestion by macroinvertebrates did not reflect feeding behaviour, with both filter-feeding and grazing taxa having similar microplastics abundance. This non species-specific MP ingestion across three invertebrate taxa indicates the potential for widespread entry of microplastics at the lower trophic levels of riverine food webs. The ingestion of microplastics, however, is not fully explained simply by the abundance of MPs, and depends on the characteristics of MPs (e.g. size, density, shape and polymer type), as well as biological factors and life history traits (Sidney et al., 2016). Some taxa may actively ingest MPs through the selection of specific particles, whereas others may accidentally ingest plastics during feeding. For example, sediment ingesting taxa such as Lumbricidae may be more likely to inadvertently ingest MPs, whereas filter-feeding taxa may select MPs based upon their relative dimensions. Furthermore, the characteristics of MPs may dictate their distribution (vertical and horizontal) within river systems, and therefore the bioavailability of MPs. A range of different characteristics are likely responsible, including density, shape and surface-area to volume ratios. Modelling studies have indicated the potentially limited role of particle density in partitioning MPs within river systems (Besseling et al., 2017). The relative importance of other MP characteristics, however, remain unknown. Biological traits, such as habitat affinity, may also be responsible for observed differences, with reduced presence of microplastics in Baetidae suggesting that organisms inhabiting water columns, are less likely to encounter and ingest microplastics. Hydropsychidae and Heptageniidae, on the other hand, are typical of coarse sediment and subsurface environments (Tachet et al., 2002), and hence habitats within which MPs are likely to aggregate and be retained (Besseling et al., 2017). Care is needed, however, in extrapolating from taxa in this study to other invertebrates, and we advocate a more comprehensive analysis of the influence of biological traits on microplastic ingestion.

Once incorporated within food webs, the transfer of MPs may present a risk to secondary consumers. Trophic transfers of microplastics have so far only been identified within marine systems (Nelms et al., 2018), where analyses of microplastics indicate an increased likelihood of occurrence and greater abundance of microplastics at higher trophic levels (Nelms et al., 2018). In contrast, the trophic cascading of MPs in freshwater ecosystems has scarcely been investigated. Although our findings indicate the initial entry of MPs into the lower trophic levels of riverine food webs, microplastics are now observed in the guts of predatory fish in UK river systems (Horton et al., 2018). Further biomagnification within food webs is likely to be affected by MP egestion rates, for example if the majority of ingested microplastics is egested rather transferred through food webs, but available data are scarce. Our work shows that such egestion can occur, but some MP residues clearly persisted in our samples.

Beyond illustrating the microplastics are entering freshwater ecosystems, probably from both diffuse and point sources, available research does yet offer an effective assessment of their ecological risks in running or standing waters. A range of direct and indirect biological effects of microplastic ingestion are possible (Lee et al., 2013; Wright et al., 2013a; Au et al., 2015; Cole et al., 2015) but most investigations lack environmental realism (Lenz et al., 2016). The concentration and size of MPs utilised in controlled exposure studies generally do not correspond to those observed in field-based studies of natural systems (Phuong et al., 2016). As a result, the direct effects of MPs, such as the blockage of digestive tracts, could easily be overestimated, while measurements of indirect effects such as the transfer of xenobiotic pollutants from plastic to organisms might not be accurately assessed. As shown by Koelmans et al. (2016) when the results of existing studies are adjusted to simulate environmentally relevant concentrations of MPs, pollutant ingestion from prey tissues items could well constitute a greater toxic risk than microplastics. Similarly, experimental assessments on *Gammarus pulex* demonstrate a low likelihood of effects on individuals, with no observed effects derived from the ingestion of polyethylene terephthalate particles (10–150 μm) (Weber et al., 2018). These limited effects are corroborated from experiments assessing the effects of microplastics on other freshwater invertebrates, with no effects observed for any taxon or any biological endpoint with the exception of reduced growth in *G. pulex* (Redondo-Hasselerharm et al., 2018). However, with such a dearth of data on the occurrence, concentrations or possible mechanisms of microplastic effects on freshwater invertebrates, the understanding of ecological risk is seriously limited.

In conclusion, our data demonstrate the presence of microplastics in multiple species of riverine macroinvertebrates thereby highlighting a potential risk in freshwater ecosystems, and signposting the need for further work. In particular, research is required to link target organisms to the sources and fluxes of plastics, to assess the transfer of microplastics within freshwater food webs, and to guide remediation from the basis of a more complete biological risk assessment than is currently available for any freshwater ecosystems.

Conflict of interest statement

The authors declare no conflicts of interest.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2018.07.271.

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1. Thank you for the invitation to submit evidence to the ongoing inquiry into microplastics by the National Assembly's Climate Change, Environment and Rural Affairs Committee.

2. I am a postgraduate researcher at Cardiff University focusing on the transfers and effects of persistent pollutants, including (micro)plastics, in river systems.

3. As part of a collaboration between Cardiff University and the University of Exeter we have been investigating the interactions between aquatic organisms and microplastics in rivers across South Wales.

4. The following paragraphs address the four questions posed by the Committee.

To what extent are microplastics, including synthetic microfibers, a problem within Wales' aquatic environment? How does this impact on environmental and human health?

5. Data from the rest of the UK and other regions of the globe indicate that microplastics are potentially ubiquitous across aquatic ecosystems.

6. There remains relatively limited information about the distribution of microplastics in Wales' aquatic environment. Data collected in our recently published research suggests that microplastics are present across a range of river systems in South Wales (https://www.sciencedirect.com/science/article/pii/S0048969718327669). The data presented therein, however, are confined to predominantly urban river systems.

7. Our understanding of the environmental problems generated by microplastics is relatively rudimentary. Although a large body of laboratory-based evidence suggests potential negative effects, recent studies have indicated that perceived risk from plastic pollution may not represent the actual effects observed in natural systems (https://pubs.acs.org/doi/abs/10.1021/acs.est.7b02219). Further research is required to better understand the environmental effects of microplastics.

8. The effects of plastic on humans has received little attention. Indirect links between plastics and human health have been generated with plastic associated chemicals, such as phenols and phthalates, observed in humans. Questions, however, remain over the relative toxicity of these compounds to humans (http://rstb.royalsocietypublishing.org/content/364/1526/2153.short). Direct links between microplastics and human health are uncommon. Recent studies have shown that microplastics are present in both commercial bottled water (https://www.sciencedirect.com/science/article/pii/S0043135417309272) as well as tap water (Helmholtz Centre for Polar and Marine Research), but associated health risks remain speculative.

What are the main sources of microplastic pollution, including microfibres?

9. There appear to be a wide range of microplastic pollution sources across the aquatic environments. Sources, identified across multiple studies in different regions of the world, include; wastewater treatment works, storm/road drains, combined sewage overflows, litter, degradation of larger macroplastics and reapplication of sewage sludge across agricultural areas. There are also a number of perceived/potential sources which have yet to be adequately investigated.

10. A comprehensive review of sources across aquatic systems is presented in a European Commission Report by ICF in association with Eunomia and partners (http://www.eunomia.co.uk/reports-tools/investigating-options-for-reducing-releases-in-the-aquatic-environment-of-microplastics-emitted-by-products/).

11. Within our study specific sources of microplastic pollution in river systems were difficult to identify. It was, however, observed that the levels of microplastic ingestion by several aquatic insects increased with increasing wastewater contributions. Nevertheless, the presence of microplastic within organisms across all sites indicates that a wide variety of sources are contributing to microplastic pollution observed in aquatic ecosystems.

How comprehensive is our knowledge about the scale of microplastic pollution and its effects? What should the research priorities be?

12. Our understanding of the distribution of plastic pollution is gradually increasing, with a growing body of research indicating the widespread nature of microplastic pollution. There remain, however, several large gaps in our knowledge. Two particularly important gaps are: (i) knowledge regarding microplastic pollution is dominated by research in marine ecosystems, with relatively few studies assessing freshwater or terrestrial habitats; and (ii) small particles (<20 μm), for example tyre dust, are below current detection limits of most analyses, so we have a poor understanding of both distribution and quantity of plastic particles of this size in the environment.

13. Knowledge regarding the effects of microplastic pollution is also limited and there is currently significant debate surrounding the difference between a range of ‘perceived’ or potential ecological effects and ‘actual’ effects from microplastic exposure (https://pubs.acs.org/doi/abs/10.1021/acs.est.7b02219). As eluded to previously, several of these perceived risks have been shown to less severe than expected in experimental investigations. Many other potential mechanistic effects, however, remain unexplored and subsequently our understanding of environmental effects is uncertain. Improving knowledge of the effects of microplastic pollution in natural systems is important.

14. A number of recent projects have been commissioned to assess plastic pollution in aquatic environments, including the “*Plastic Rivers: fate and transport of microplastics in rivers*” led by investigators at the University of Birmingham and funded by the Leverhulme Trust. Several other industry funded projects are also currently in operation. The data derived from these projects look to improve our understanding of plastic pollution in aquatic ecosystems.

What is currently being done to minimise the release of microplastics into the environment? What more can be done, and by whom, to address this issue within Wales?

15. The large number of potential sources of plastic pollution indicates that an integrated strategy is required to address the release of plastic into the environment across the entire life cycle of plastic.

16. It appears crucial to prevent the entrance of plastic into the environment, as remediation of existing plastic pollution is extremely difficult and expensive. A range of activities are currently aimed at minimising the entrance of microplastics into the environment. A few examples include; manufacturers promoting reduced washing of synthetic clothing (e.g. Patagonia) and developing alternative technologies for the reuse of plastics (e.g. Thermal Compaction Group), water companies working towards more effective methods of removing microplastics during wastewater treatment (e.g. Dwr Cymru Welsh Water) and volunteer groups removing litter from rivers and coastlines (e.g. Thames21).

17. Public engagement has been critical thus far, and appears particularly important in the future. Knowledge exchange partnerships, such as the UK Microplastics Network (http://www.ukmicroplasticsnetwork.co.uk) provide a platform through which stakeholders in plastic production and utilisation are able to interact. Interactions between stakeholders enables a range of activities that may lead to a reduction in plastic waste, including: behavioural change, identifying suitable alternatives for single-use plastics, improved removal of plastics from wastewater and changes to supply chain management.

Agenda Item 3

Cynulliad Cenedlaethol Cymru | National Assembly for Wales
Y Pwyllgor Newid Hinsawdd, Amgylchedd a Materion Gwledig | Climate Change, Environment and Rural Affairs Committee
Ymchwiliad Microblastigau | Microplastic Inquiry

Ymateb gan : Cymdeithas Cadwraeth Forol
Evidence from : Marine Conservation Society

Thank you for giving the Marine Conservation Society (MCS) the opportunity to provide evidence to the CCERA Committee's inquiry on the impact of microplastic pollution in Welsh waterways. Please find our response to each question below:

1. **To what extent are microplastics, including synthetic microfibers, a problem within Wales' aquatic environment? How does this impact on environmental and human health?**

Introduction

Plastic use and production in the UK are set to rise. It has been estimated that current (2018) waste arising are estimated at 5.2 million tonnes, and are forecast to increase to around 6.3 million tonnes by 2030 ï a 20% increase over this 12 year period[1].

Plastics have been found in all environments from remote Swiss high mountain areas[2] to the ocean trenches[3] and Antarctic ice[4] . Traces of microplastics have also been found in bottled[5] and tap water[6], beer[7], honey[8] and even the air we breathe[9].

It is important to note that macroplastics (larger plastic items) are also having a devastating effect on our aquatic environment: they contribute to the entanglement, starvation and smothering of marine and freshwater organisms. Macroplastics are also a key source of microplastic pollution once larger plastic pieces break down. Our written evidence will also therefore include impacts and solutions to the problem of macroplastic pollution.

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It is vital that we reduce our use and dependence on plastics and that we stop the flow of plastics to our rivers, seas and oceans, if we are to have any chance of turning the tide on this form of pollution.

Microplastics definition

ñMicroplasticsò are defined as plastic particles less than 5mm in size in any one dimension. There are 2 main types of microplastics:

1. Primary microplastics - these are purposefully manufactured small bits of plastics added to items such as ñmicrobeadsò, which, up until recently, were commonly used as ingredients in personal care products. These are also still to be found in cosmetics, industrial and household cleaners and industrial air blasting media. Pre-production pellets, the óraw materialô of many plastic items, are also a significant source of primary microplastics.

2. Secondary microplastics ï these arise from the breakdown of larger plastic items on land or at sea. These include obvious sources such as polystyrene trays or plastic bottles that may take many years to break down in the aquatic and marine environment, and less obvious sources such as fibres from washing clothes, tyre wear and tear, road paint abrasion and the spreading of sewage sludge containing microplastics onto land.

Within our response to this call for evidence, we address the problems and solutions of both primary and secondary microplastics.

The extent to which microplastics are a problem

In our joint eNGO briefing on microbeads, March 2016, MCS, along with the Environmental Investigation Agency, Greenpeace and Flora and Fauna International, highlighted the reasons why microplastics are a serious concern:

- They are eaten by aquatic life at all stages of the food chain, from plankton through to fish and marine mammals, including species important to fisheries and ecosystem function[10] (the following video visually demonstrates plankton ingesting microplastics)
- The transfer of microplastics up the food chain has been demonstrated[11] [12]
- They release toxic chemicals into the surrounding water, and also attract chemicals onto their surface, which can have toxic impacts on living organisms[13] [14]

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- They persist in the environment for hundreds of years;
- They have been found in every ocean and in all marine habitats;
- Once released into the marine environment, it is impossible to clean them up.

Microplastics are now ubiquitous throughout the worldôs oceans ï at the sea surface, in the water column, in sediments and even concentrated in Arctic Sea ice. Between 15 and 51 trillion tiny plastic particles are estimated to be floating in the worldôs oceans.[15]

Impacts on Environmental Health

Ingestion and entanglement

Market surveys of fish being sold for consumption in the U.S. found plastic in 67% of all species and 25% of individual fish.[16] The impacts of plastic ingestion (both macro and microplastics) include gut blockage and physical injury, oxidative stress, altered feeding behaviour and reduced energy allocation, resulting in impacts on growth and reproduction in a range of marine invertebrates, including crabs, lugworms and oysters.[17]

In the UK, 83% of Norway lobster (typically sold as scampi) has been found to contain plastics[18] and plankton sampling demonstrates a significant increase in the abundance of plastics from the 1960s to the present day.[19] [20] Scientists estimate that European seafood consumers could be consuming up to 11,000 microplastics per year.[21]

There is also compelling evidence to suggest that macroplastic ingestion effects significant levels of marine wildlife: Gall & Thompson (2015) reported that all species of sea turtles, 54% of marine mammals and 56% of all sea birds have been affected by entanglement in, or ingestion of, marine debris, 92% with plastic. Additionally 17% of species affected were listed as between threated to critically endangered on the IUCN red list[22].

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[17] Sussarellu R, et al. (2016) Oyster reproduction is affected by exposure to polystyrene microplastics. Proc Natl Acad 14 Sci USA 113:2430–2435; Watts AJR, Urbina MA, Corr S, Lewis C, Galloway TS (2015) Ingestion of Plastic Microfibers by the Crab Carcinus maenas and Its Effect on Food Consumption and Energy Balance. Environ Sci Technol 49(24):14597–14604; Wright SL, Rowe D, Thompson RC, Galloway TS (2013) Microplastic ingestion decreases energy reserves in marine worms. Curr Biol 23(23):R1031–R1033; Cole M, Lindeque P, Fileman E, Halsband C, Galloway TS (2015) The impact of polystyrene microplastics on feeding, function and fecundity in the marine copepod Calanus helgolandicus. Environ Sci Technol 49(2):1130–1137.

[18] Murray, F. & Cowie, P. 2011. Plastic contamination in the decapod crustacean Nethrops norvegicus. Marine Pollution Bulletin. 67(1-2): 200-202.

[19] Thompson, R.C., Olsen Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D. & Russell AE (2004) Lost at sea: Where does all the plastic go? Science 304: 838.

[20] Thompson, R. and Hoare, C. (1997). Microscopic plastic - A shore thing. Marine Conservation 3 (11)

[21] Van Cauwenberghe, L., Janssen, C. (2014) Microplastics in bivalves cultured for human consumption. Environmental Pollution. V. 193, 65–70

[22] Gall, S.C. and Thompson R.C. (2015) The impact of debris on marine life. Marine Pollution Bulletin 92 (2015) 170–179

Concentrating toxic compounds

Toxic compounds such as plasticisers, fire retardants and other additives are incorporated into microplastics during production.[23] Microplastics can also attract persistent, bioaccumulative and toxic pollutants from seawater such as the endocrine disruptors Polychlorinated Biphenyls (PCBs) and Dichlorodiphenyldichloroethylene (DDEs).[24] Microplastics can concentrate PCBs and DDEs to levels up to a million times greater than in the surrounding seawater.[25]

PCBs are linked to reproductive toxicity and population declines in marine mammal populations, and their biomagnification in marine food webs continues to cause severe impacts in top predators in European seas.[26] [27] Whilst the extent to which these contaminants are transferred from ingested plastics into living tissues is as yet unknown, there is evidence that PCBs found in the flesh of Great Shearwaters were derived from ingested plastic particles.[28]

Impacts on Human Health

With microplastics and their associated contaminants readily ingested by organisms throughout the food chain, and well documented in a range of species consumed as seafood, there is a potential danger that these pollutants may be passed up the food chain to human consumers.

As previously mentioned, scientists estimate that European seafood consumers could be consuming up to 11,000 microplastics per year. However this is an area of ongoing research and more is needed to assess the extent of ingestion of microplastics through fish and shellfish. The World Health organisation is currently looking into the possible risks of microplastics in bottled water[29].

2. What are the main sources of microplastic pollution, including microfibres?

The recent OSPAR report gives an indication of the relative proportions of several of the main types of microplastic (figure 1 below)[30].

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[23] Mato Y (2001).Plastic resin pellets as a transport medium for toxic chemicals in the marine environment. Environmental Science and Technology 35 (2): 318-324

[24] Takada H, Mato Y, Endo S, Yamashita R, Zakaria M (2006). Pellet Watch: Global monitoring of persistent organic pollutants using beached plastic resin pellets.

[25] Ananthaswamy, A. (2000). Junk Food - a diet of plastic pellets plays havoc with animals' immunity. New Scientist, 20/01/01.

[26] Jepson, P., Deaville, R. et al., (2016). PCB pollution continues to impact populations of orcas and other dolphins in European waters. Scientific Reports 6, 18573.

[27] Fossi, M., Marsili, L., Baini, M., Gianetti, M., Coppola, D., Guerranti, C., Caliani, I., Minutoli, R., Lauriano, G., Finoia, M., Rubegni, F., Panigada, S., Berube, M., Ramirez, U. & Panti, C. (2016). Fin whales and microplastics: The Mediterranean Sea and the Sea of Cortez scenarios. Environmental Pollution, 209: 68-78

[28] Ryan, P.G., Connell, A.D., Gardener, B.D. (1988). Plastic ingestion and PCBs in seabirds: is there a relationship? Marine Pollution Bulletin 19(4): 174-176.

[29] https://www.theguardian.com/environment/2018/mar/15/microplastics-found-in-more-than-90-of-bottled-water-study-says

[30] OSPAR commission (2017) Assessment document of land-based inputs of microplastics in the marine environment

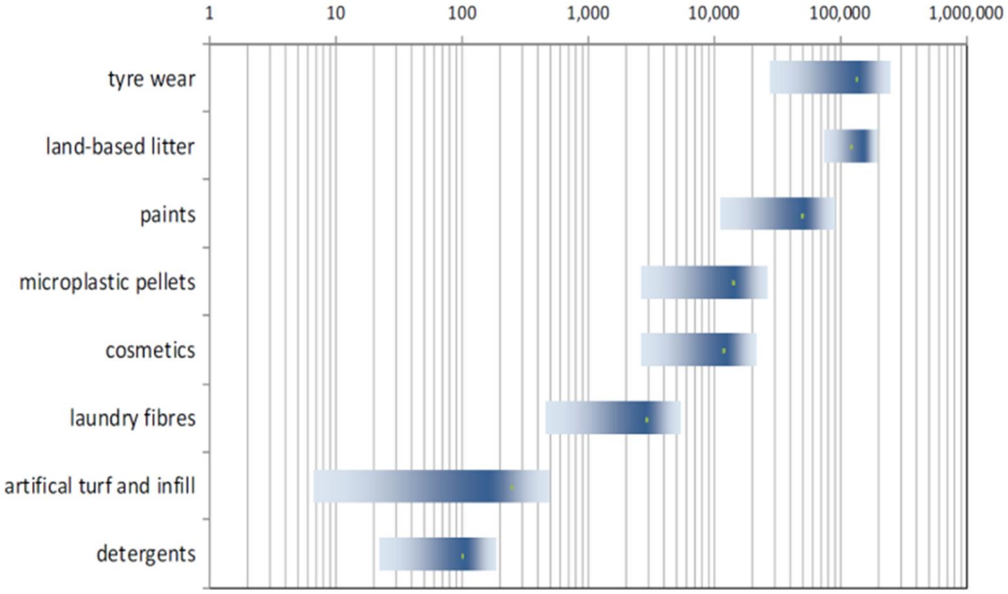

Figure 1: Estimated emissions of microplastics in OSPAR catchments (tonnes / year). The bars represent the uncertainty margins of the emission, white dots represent the midpoint.

The above figure indicates that it is likely that land-based macroplastics (litter) is the cause of some of the highest emissions of microplastics in OSPAR countries. Notable also is the higher level of certainty assigned to the amount of emissions from land-based litter source of microplastics compared to others, suggesting there is a greater body of evidence to equate microplastics to the breakdown of larger plastic items. The following information seeks to summarise some of the key sources of primary and secondary microplastic pollution:

Primary microplastics

Pre-production plastic ópelletsô

Although mostly referred to as pellets, these actually come in the form of pellets, flakes and powders all <5mm. A recent Eunomia report demonstrated that pre-production pellet loss to the environment in the UK is likely to be at least 105 tonnes, and possibly as high as 1,054 tonnes each year. These tonnages equate to 5 billion and 53 billion pellets per annum respectively.[31]

Pellets can be lost at any point in the plastics supply chain: producers, distributers, storage points, ports, transport over sea, and during waste management and recycling. Pellets are lost when spills are not completely cleaned up. These pellets can be washed into drains or directly into waterways by surface water runoff if spills occur outside. Spillages of containers at sea also contribute to microplastics in the marine environment. The Eunomia study highlights that some of the key points for pellet loss to take place are loading bays, storage for use and storage for disposal. The greatest risk is from spills from bags and boxes during handling and transportation.

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[31] Sherrington, C. (2016). Study to Quantify Pellet Emissions in the UK, Eunomia Report to Fidra

Microbeads

Although there is a ban on the use and sale of some personal care products containing microbeads across the UK they are still found in some cosmetics, industrial and household cleaning products and air blasting media. In Europe, cosmetic microbeads could be adding up to 8,627 tonnes of plastic per year to the marine environment[32].

Secondary microplastics

Macroplastics ï the breakdown of larger items

The EU Marine Strategy Framework Directive (MSFD) defines marine litter as ñany persistent, manufactured or processed solid material discarded, disposed of or abandoned in the (marine and coastal) environmentö[33].Considerable progress has been made in the determination of the amount and location of plastic litter in our seas.

Now in its 25th year, the Marine Conservation Societyôs ôBeachwatchô programme holds extensive data on the volume and types of litter being found on our beaches. Last yearôs results (2017) showed that on average 718 pieces of litter were found on every 100m stretch of beach surveyed within the UK.

Surveys undertaken on 25 beaches in Wales over the same weekend in September 2017 shows that the average amount of litter collected has increased by 11% since 2016 (now equating to an average of 677 items per 100m stretch). The amount of single use plastic items found, such as bottles, coffee cups, lids, straws and takeaway containers, increased by 13%.

Plastic and polystyrene pieces continue to rank 1st in litter items found (avg. 255 pieces per 100m in the UK), with food packaging, and plastic caps and lids, also ranking in the top 5 items littered. Cigarette butts, wet wipes and the remains of plastic cotton buds sticks, were also within the top 10 litter items found in the UK.

Plastic litter will contribute significantly to the release of microplastics into the marine environment, when nothing is done to remove the existing plastic mass and reduce the influx of litter. It is often stated that approximately 80% of marine litter arises from land-based sources and the remaining 20% come from sea-based sources[34].

Fibres from washing clothes

One of the first studies on fibre release from laundry in relation to environmental exposure was published by Browne et al.[35]

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[32] Sherrington, C., Darrah, C., Hann, S., Cole, G., Corbin, M. (2016). Study to support the development of measures to combat a range of marine litter sources. Report for European Commission DG Environment

[33] Galgani, F., D. Fleet, J. van Franeker, S. Katsanevakis, T. Maes, J. Mouat, L. Oosterbaan, I. Poitou, G. hanke, R. Thompson, E. Amata, A. birkun, and C. Janssen, 2010, Marine Strategy Framework Directive. Task Group 10 Report. Marine Litter, JRC, EUR 24340, 57 pages.

[34] UNEP, 2014, Valuing plastics: The business case for measuring, managing and disclosing plastic use in the consumer goods industry, United Nations Environment Programme, 116 pages.

[35] Browne, M.A., P. Crump, S.J. Niven, E. Teuten, A. Tonkin, T. Galloway, and R. Thompson, Accumulation of Microplastic on Shorelines Woldwide: Sources and Sinks. Environmental Science & Technology, 2011. 45(21): p. 9175-9179

They found that up to more than 1900 fibres per garment, per wash, or 100-300 fibres per litre effluent could be released.

The amount of microfibre released from clothing can vary greatly, however de Falco et al[36] highlight factors which may contribute. This is in a large part down to the fabrics, laundry products and washes used:

- An increased amount of microfibres is released by woven polyester
- Softener and bleach reduce fibres’ damage and breaks
- High temperature, washing time and mechanical action increase microfibre release

Falco et al found that the number of microfibres released from a typical 5 kg wash load of polyester fabrics was estimated to be over 6,000,000 depending on the type of detergent used. The usage of a softener during washes reduces the number of microfibres released of more than 35%. Importantly, the amount and size of released microfibres confirm that they cannot be totally retained by wastewater treatments plants, and will therefore escape into the aquatic environment.

Road dust from tyres, pavements and road markings

Rubber in tyre treads, polymers added to strengthen the bitumen used in road pavement, and thermoplastic elastomers in road marking paints, are believed to be the main contributors to microplastic particles in road dust.

It is believed that the majority of road-dust associated microplastic particles enter the environment as runoff from the road and road verges. Since the weather is such an important factor for local distribution, runoff may vary day to day and with season. A current report produced for the Environment Agency of Norway[37] suggests there is a lack of evidence to enable us to understand the extent to which these microplastic particles are removed by existing waste water treatment facilities.

Sewage sludge

Most household waste water is treated at municipal sewage treatment plants (STP). Many industries have their own treatment installations or filters at their disposal. Microplastics are not recycled and, due to their limited size, it is difficult for sewage treatment plants to filter all microplastics out of the water. Only limited data is available on the treatment efficiency of sewage treatment plants regarding microplastics.

In a study conducted by the VU University Amsterdam[38], research was conducted into the presence of microplastics in various flows at the Heenvliet sewage treatment plant. In this

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[36] Francesca De Falco,Maria Pia Gullo,Gennaro Gentile,Emilia Di Pace,Mariacristina Cocca,Laura Gelabert,Marolda Brouta-Agnésa,Angels Rovira,Rosa Escudero,Raquel Villalba,Raffaella Mossotti,Alessio Montarsolo,Sara Gavignano,Claudio Tonin et al. 2018, Evaluation of microplastic release caused by textile washing processes of synthetic fabrics, Environmental Pollution, Volume 236, May 2018, pages 916-925

[37] Christian Vogelsang, Amy L. Lusher, Mona E. Dadkhah, Ingrid Sundvor, Muhammad Umar, Sissel B. Ranneklev, David Eidsvoll and Sondre Meland. (2018). Microplastics in road dust – characteristics, pathways and measures. Norwegian Insitute for Water Research report to the Norwegian Environment Agency.

[38] Leslie, H., M. Moester, M. de Kreuk, and D. Vethaak, Verkennende studie naar lozing van microplastics door rwzi's. H2O, 2012. 14/15: p. 45-47.

exploratory study, 90% of the microplastics were removed by the treatment process. This means that the remaining 10% enters the surface water, from where it can reach the sea.

A 2016 study suggests that the practice of spreading sewage sludge (a bi-product of water treatment) onto farmlands may result in between 125 and 850 tons microplastics/million inhabitants being added annually to European agricultural soils either through direct application of sewage sludge or as processed biosolids. The environmental and/or human health consequences of this are unknown[39].

Furthermore, it is estimated that approximately two thirds of laundry fibres are retained in sewage sludge. Depending on national policies on the spreading of sewage sludge on land, these emissions could enter the environment, and could be redistributed to surface water through runoff into rivers[40].

3. How comprehensive is our knowledge about the scale of microplastic pollution and its effects? What should the research priorities be?

Research into the impacts of microplastics

The full consequences of impacts of ingestion of microplastics on wildlife and human health are not yet fully understood and would benefit from greater research, particularly for óscaling upôof impacts e.g. how do we estimate the impact of microplastic ingestion in laboratory studies on plankton to wild populations in rivers, seas and oceans?

Dafne et al (2015) suggest the following research on all microplastics is needed to better understand human impacts:

- Transfer of chemicals to food; either chemicals inherent in microplastics or chemicals sorbed and transported by microplastics.
- Interactions of fishery/aquaculture species with microplastics and whether these interactions affect the edibility or marketability of fish/aquaculture species.
- Whether application of sewage sludge to terrestrial systems for agricultural reasons may lead to transfer of microplastics and/or chemicals to soil used in growing food.
- Economic considerations, such as whether microplastic presence in aquaculture species could lead to loss in revenues, or the extent of costs associated with clean-up efforts[41].

That said, there is a growing body of evidence to suggest impacts could be significant, particularly for the wide ranging impacts from macroplastics on the marine environment (see response to question 1), so whilst knowledge of the environment and human health impacts and the associated costs is far from complete, there is already a strong case to act now.

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[39] Nizzetto, L., Futter, M. and Langaas, S. (2017) ‘Are agricultural soils dumps for microplastics of urban origins?’, Environmental Science & Technology

[40] OSPAR commission (2017) Assessment document of land-based inputs of microplastics in the marine environment, page 25

[41] Dafne, E., Thompson, R., Aldridge, D., 2015. Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. Water Research, Vol 75 (2015), pg 63-82. http://wedocs.unep.org/bitstream/handle/20.500.11822/17933/Microplastics_in_freshwater_systems_A_review.pdf?sequence=1

Understanding the pathways of microplastics

Dafne et al[42] point out that, given that the study of microplastics in freshwaters has only arisen in the last few years, we are still limited in our understanding of:

- their presence and distribution in the environment;
- their transport pathways and factors that affect distributions;
- methods for their accurate detection and quantification;
- the extent and relevance of their impacts on aquatic life.

Specific types of microplastic that would benefit from a greater research include:

- Plastic pre-production pellets **-** A larger volume of research into pellet loss has been carried out in the US than in the UK and, as a consequence, the Eunomia report into UK plastic pellet emissions looks to the US for current research and findings. Further research into pellet loss in the UK, including the key causes and amount of loss, would enable a greater understanding of this issue and would help to support solutions to this problem in Wales.
- Pathways and impacts of microbeads and microfibres (see recommendations from Dafne et al above)
- Road dust from tyres, pavements and road markings - There is generally a lack of evidence to enable understanding of the levels of road-dust associated microplastic particles present in road runoff entering existing waste water treatment facilities, and the extent to which these microplastics can be removed. There also appears to be limited documentation regarding the presence of microplastic particles from road marking paints in the environment. Macroplastic littering could also be an important secondary source to microplastics in road dust.
- Sewage sludge - more research is needed on: the sources of microplastic contained within sludge (including from the washing of synthetic clothes) and at what levels; the levels of microplastics that escape through sewage treatment plants, and; the rate at which microplastics escape from spread on farmland to surrounding waterways.
- Macroplastics as a source of microplastic - in Wales, more research is needed on: the identification of the sources of Welsh litter; the rivers and beaches in Wales which may be accreting or disposing litter; identification of the types of litter found; and, solutions to reduce litter at source (such as understanding the feasibility of introducing a Deposit Return System for single use items in Wales ï see response to question 4).

Increasing the level of understanding in these areas is essential if we are to develop appropriate policy and management tools to address this emerging issue.

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[42] Dafne, E., Thompson, R., Aldridge, D., 2015. Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. Water Research, Vol 75 (2015), pg 63-82. http://wedocs.unep.org/bitstream/handle/20.500.11822/17933/Microplastics_in_freshwater_systems_A_review.pdf?sequence=1

4. What is currently being done to minimise the release of microplastics into the environment? What more can be done, and by whom, to address this issue within Wales?

Although the origins of primary and secondary microplastics may differ, both are a persistent problem for marine and aquatic life which need to be addressed as a matter of priority. Furthermore, eliminating microplastic and indeed all plastic pollution at source is the only viable way forward financially, technically, and environmentally.

Primary microplastics

Microbeads

On the 30th June 2018, a ban on the production and sale of products containing microbeads in cosmetics came into force in Wales under the Environmental Protection (Microbeads) (Wales) Regulations 2018. This is a significant step towards reducing sources of plastics to the marine environment. However, to be effective, the ban must be effectively enforced and must be extended to include microbeads contained in other products such as industrial and household cleaning products and leave on cosmetics.

Pre-production plastic ópelletsô

The Eunomia report into plastic pellet emissions in the UK[43] highlight that key factors resulting in pellet loss include:

- How pellets are packaged for transport ï pellets in bags and boxes are easier to spill than tankers;
- Whether pellets are handled inside or outside ï spills inside are much easier to contain and clean up;
- Manual vs. machinery handling ï greater risk of spillage from manual handling;
- How waste pellets are stored for disposal; and
- Management practices employed ï to reduce spills and losses.

The report recommends that the UK plastic industry establishes the effectiveness of the pellet loss reduction measures contained in Operation Clean Sweep (the industryôs best practise approach to addressing pellet loss). The report also recommends that the plastics industry and other stakeholders work to address information gaps to improve the estimates of pellet loss to determine how best to focus further action. This could in part be achieved through establishing the effectiveness of Operation Clean Sweep.

The report also recommends establishing a means for enforcement and prioritising resources for enforcement to reduce plastic pellet loss. Enforcement can be part of the solution to addressing pellet loss but it may require legislative tools and resources. A shorter term approach would be industry funded self-regulation, involving third party measurements and spot checks on facilities.

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[43] Sherrington, C. (2016). Study to Quantify Pellet Emissions in the UK, Eunomia Report to Fidra

Secondary microplastics

Macroplastics ï breakdown of larger items:

Current initiatives at the Welsh Governmentôs disposal to reduce introduction of macroplastics into the environment include:

- Creating a circular economy: Macroplastics in our aquatic and maritime environments are a visual sign of a failure to achieve a circular economy. Working with industry and the public, the Welsh Government must focus more on the reduction of, rather than the recycling of, materials. Best practise, from how products are designed, to how they are recycled, must be incentivised to ensure material and resources are valued. Initiatives that must be taken forward include:
    - Extending Producer Responsibility (EPR): The objective of extended producer responsibility (EPR) schemes are to ensure that responsibility for collecting or taking back used goods, and for sorting and treating for their eventual recycling, lies with producers. Such responsibility may be simply financial or, additionally, organisational. EPR is consistent with the polluter pays principle in that it is intended to shift the end-of-life costs away from citizens/taxpayers, towards producers/consumers. It can also be designed in such a way as to provide financial incentives to design products and packaging so as to facilitate recycling at the end of life. Under the UKôs current approach to producer responsibility for packaging, which is very different to most other packaging EPR schemes in Europe, it is estimated that only 10% of the costs of dealing with the materials at end of life are covered by producers. The rest are covered by taxpayers. This leads to very little incentive to improve practices.
    - A tax or levy on single use items: MCS Beachwatch data demonstrates that between 2016-7 the amount of single-use plastic found on beaches (such as bottles, coffee cups, lids, straws and takeaway containers) increased by 13% in Wales. The success of the carrier bag charge in Wales demonstrates that placing a value on a single-use item is effective in changing consumer behaviour.
    - Deposit return systems (DRS) for drinks containers: This initiative already work well in over 40 countries or states worldwide including parts of Australia, Norway, Lithuania and some US states. In South Australia, which has a DRS, only 2.9% of litter is beverage containers. In Western Australia, with no DRS, drinks containers make up 13% of litter[44]. Such systems can reduce littering, increase high quality recycling and reduce costs for local authorities. Like the carrier bag charge, it is a simple idea that can have an immediate effect. As of the 8th May 2018, the Welsh Government has committed to explore the feasibility of introducing DRS in Wales working together with the rest of the UK, however, no timescale has been committed to this, and it is yet to become clear how this will work. Should there be

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[44] Eunomia. (2017) Impacts of a Deposit Refund System for One-way Beverage Packaging on Local Authority Waste Services. Report commissioned by Keep Britain Tidy, Campaign to Protect Rural England, Marine Conservation Society, Surfers Against Sewage, Reloop, Melissa and Stephen Murdoch. https://www.mcsuk.org/media/eunomia-report-on-drs.pdf

delays within the other Devolved Administrations, Wales should commit to taking this commitment forward at a national scale.

- Additional behaviour change initiatives: such as the eco-schools (litter education) programme, fixed penalty notices (FPN) for littering, and public awareness initiatives such as MCS’s Stop the Unflushables (wet wipes), Don’t Let Go (ban on balloon and sky lanterns), and Stop Sucking (ban on straws) campaigns.

- Funding clean-up operations: such as booms for rivers, and beach and river clean-ups, although these should be viewed as a ‘last resort’ for stopping litter from impacting on our riverine and marine environments.

Road dust from tyres, pavements and road markings

In addition to sustainable drainage systems and compact technical treatment units, in the 2018 report produced for the Norwegian Environment Agency, several novel ideas have been suggested which have the potential to minimise the amount of road dust associated microplastic particles from entering the aquatic and marine environments via rainwater runoff. One additional option could be to apply ‘nature-based’ solutions to retain and prevent runoff on the surface, and where needed and possible, treat the runoff, by infiltration in native soil as close to the source area as possible. The operational performance and need for maintenance of this low-cost solution would also be easy to monitor.

Microfibres

The Plastic Pollution Coalition have produced a comprehensive list of ways in which consumers can reduce the amount of microfibres escaping during washes. Notable actions include:

- Purchasing clothing made from natural fibres, such as cotton, linen and wool. Natural fibres will eventually break down in the environment, whereas plastic fibres will never go away.
- Washing synthetic clothes less frequently, and for a shorter duration.
- Using a cooler wash setting: Higher temperature can damage clothes and release more fibres.
- Use laundry liquid as opposed to powder: laundry powder “scrubs” and loosens more microfibres.
- Purchasing a ‘wash bag’ to contain clothing when washing which enables consumers to dispose of microfibres collected responsibly.
- Purchasing a washing machine discharge filter which is able to screen out synthetic microfibres.

Please do not hesitate to contact us if you wish to discuss any part of our evidence.

Gill Bell, Head of Conservation (Wales), Marine Conservation Society

October 2018

Briefing

Microplastic pollution in Wales

Submission to the Climate Change, Environment and Rural Affairs Committee | Y Pwyllgor Newid Hinsawdd, Amgylchedd a Materion Gwledig

Summary

- Microplastic pollution is widespread and comprises many forms and sources.
- Understanding of the impact on wildlife is rapidly developing but examples of harm are already well documented. There is potential for serious damage at ecosystem level, and human health is also at risk.
- Research and action most focus on prevention of plastic pollution through radical reduction of use of most plastics.
- A better understanding of plastic pollution sources and their pathways to and through the environment is also required, but there are immediate steps that can be taken reduce pollution from Wales.
- Wales should consider legislation committing to a pathway to near-zero plastic pollution, and classing plastic as a pollutant.

1. **To what extent are microplastics, including synthetic microfibers, a problem within Wales' aquatic environment? How does this impact on environmental and human health?**

   1.1. The rapidly growing evidence base for microplastic pollution in aquatic environments indicates widespread prevalence. It would reasonable to assume a broadly similar picture across all parts of the UK, including Wales, for reasons outlined in the response to Question 2.

1.2. The dispersibility of microplastics means they have been found in surface water, shallow waters, beaches and sediment in many different areas of the world.[1,2]

1.3. It is important that nanoplastics (generally classed as smaller than 100nm) are considered and studied too because similar, if not worse, concerns are beginning to be expressed as apply to microplastics[3].

1.4. Ways in which microplastics can cause environmental harm include:

  1.4.1. **Ingestion** - marine life at the bottom of the food chain, including plankton and small crustaceans, mistake microplastic for food. When eaten, these creatures transfer plastic and associated chemicals up the food chain.

  1.4.2. **Toxicological effects** - plastics often contain toxic chemicals added to lend useful features such as flexibility, and plastic debris can adsorb persistent organic pollutants (POPs) that are present in the oceans from other sources. These substances can become highly concentrated on the surface of the plastic. If ingested, these toxic chemicals in plastics could be transferred to marine organisms and cause serious harm.[4,5]

  1.4.3. Habitat impacts - microplastics provide habitats for bacterial colonisation[6] and rafting insects,[7] acting as vectors for invasive species and disease. They can also affect the temperature and oxygen concentration of marine sediments,[8] increase disease in coral and sea grass, and block light necessary for photosynthesis in these organisms.[9,10]

  1.4.4. Climate change –Recent research[11] has revealed that plastic releases methane under the action of sunlight, meaning plastic pollution could

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[1] Barnes, D.K.A., Galgani, F., Thompson, R.C., and Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1985–1998

[2] Song, Y.K., Hong, S.H., Jang, M., Kang, J.-H., Kwon, O.Y., Han, G.M., and Shim, W.J. (2014) Large Accumulation of Micro-sized Synthetic Polymer Particles in the Sea Surface Microlayer, *Environmental Science & Technology*, Vol.48, No.16, pp.9014–9021

[3] Rios Mendoza, L.M., Karapanagioti, H., and Álvarez, N.R. (2018) Micro(nanoplastics) in the marine environment: Current knowledge and gaps, *Current Opinion in Environmental Science & Health*, Vol.1, pp.47–51

[4] Teuten, E.L., Saquing, J.M., Knappe, D.R.U., et al. (2009) Transport and release of chemicals from plastics to the environment and to wildlife, *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, Vol.364, No.1526, pp.2027–2045

[5] Hirai, H., Takada, H., Ogata, Y., et al. (2011) Organic micropollutants in marine plastics debris from the open ocean and remote and urban beaches, *Marine Pollution Bulletin*, Vol.62, No.8, pp.1683–1692

[6] Carson, H.S., Nerheim, M.S., Carroll, K.A., and Eriksen, M. (2013) The plastic-associated microorganisms of the North Pacific Gyre, *Marine Pollution Bulletin*, Vol.75, No.1–2, pp.126–132

[7] Goldstein, M. (2012) *Abundance and ecological implications of microplastic debris in the North Pacific Subtropical Gyre*, 2012

[8] Carson, H.S., Colbert, S.L., Kaylor, M.J., and McDermid, K.J. (2011) Small plastic debris changes water movement and heat transfer through beach sediments, *Marine Pollution Bulletin*, Vol.62, No.8, pp.1708–1713

[9] Lamb, J. B. et al. (2017) Plastic Waste Associated with Disease on Coral Reefs, Science, Vol 359, Issue 6374, pp. 460-462

[10] https://www.blastic.eu/knowledge-bank/impacts/smothering/ ; Fitzpatrick, J., & Kirkman, H. (1995). Effects of prolonged shading stress on growth and survival of seagrass Posidonia australis in Jervis Bay, New South Wales, Australia. Marine Ecology Progress Series, 127, 279–289.

[11] https://www.bbc.co.uk/news/science-environment-45043989

potentially be a significant driver of climate change. Additionally, significant greenhouse gas emissions are associated with production of plastic which almost entirely derives from oil and, increasingly, from gas obtained through fracking.

1.5. The evidence base for human impacts is small but concerns have been raised, not least because of the evidence of harm to wildlife. Humans are exposed to micro- and nanoplastics and associated chemicals through inhalation, ingestion with food and drink and absorption through the skin.

2. What are the main sources of microplastic pollution, including microfibres?

2.1. The major sources of plastic pollution are shown in Figure 1, taken from a forthcoming report for Friends of the Earth by Eunomia. It is notable that the major microplastic pollutants comprise a greater portion of the total than the larger 'macroplastic' portion.

2.2. The estimate for microplastic pollution from vehicle tyres is particularly surprising to most people, as is the revelation that plastic pollution stems significantly from clothing and paints.

2.3. Microplastics can result from the fragmenting of larger plastic items as they are subjected to UV radiation and physical abrasion in the sea. Much plastic from items such as bottles, plastic bags and fishing nets will contribute to this.

2.4. The UK generated 4.9 million tonnes of plastic waste in 2014. Eunomia estimates, based on forward projections, 2018 waste arisings to be around 5.2 million tonnes, increasing by 20% to 6.3 million tonnes by 2030.

2.5. Eunomia estimates that the UK releases 14,500 tonnes of this plastic to the sea annually.

2.6. In the same forthcoming report Eunomia estimates the UK generates 18,000 tonnnes of microplastics from the following four main sources:

2.6.1. **Vehicle tyres**: Eunomia estimates the UK generates 60,000 tonnes per year of microplastics through tyre wear, 12,000 tonnes of which enters surface waters. Tyre dust is also estimated to contribute up to 10% of airborne particulates[12] known to cause respiratory and other illnesses.

2.6.2. **Synthetic clothing**: Eunomia estimates that 4,000 tonnes of microfibres are released from synthetic clothing in the UK annually. Of these, 1,600 tonnes per year, equivalent to 4 trillion individual polyester fibres, could pass through wastewater treatment into rivers and estuaries.

2.6.3. Fibres have been found in tap water, beer and table salt[13], and comprise a significant portion of the estimated 3-10 tonnes of plastic settling annually over Paris.[14]

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[12] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC89231/jrc89231-online%20final%20version%202.pdf

[13] Kosuth, M., et al. (2018) *Anthropogenic contamination of tap water, beer, and table salt* Plos One vol. 13(4) https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0194970

[14] Dris, R., et al. (2016) *Synthetic fibers in atmospheric fallout: A source of microplastics in the environment?* Marine Pollution Bulletin vol. 104 pp 290-293

2.6.4. The IUCN estimates[15] that 52% of microplastics remain on land (much from sewage sludge) whilst 48% head out to sea. Once applied on land, microfibres and other microplastics accumulate. They have been detected in soils 15 years after the last sludge application.[16]

2.6.5. During this time they may also be ingested by creatures above and below ground and retain the potential to be washed into streams and rivers.[17]

2.6.6. '**Nurdles'**, which are pre-production plastic pellets shipped by plastic producers, are a major source of microplastic pollution due to frequent spillage in transit. Based on industry figures[18], Eunomia estimates a UK loss rate to surface waters of 1,600 tonnes annually.

2.6.7. **Paints on buildings and road markings** contain plastic that escapes to the environment with weathering. Eunomia estimates these generate around 2,500 tonnes per year of microplastic pollution in the UK annually.

2.7. Other sources of microplastics include:

2.7.1. **Cosmetics and skincare including suncream:** Though increasingly subject to bans, these bans are at best limited to rinse-off products like shampoos, toothpastes and shower gels, and misleadingly limit the interpretation of 'microplastic' ingredients to 'beads'. Excluded products known to contain microplastics include sunscreens, makeups, hand creams and deodorants[19].

2.7.2. **City Dust**: The IUCN proposes this composite group as another important category of microplastic pollution. City Dust comprises sources such as abrasion dust from shoe soles, carpets, synthetic cooking utensils, and artificial turfs that are relatively small on their own but that amount to a significant portion in total.

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https://www.researchgate.net/profile/Rachid_Dris/publication/290182589_Synthetic_fibers_in_atmospheric_fallout_A_source_of_microplastics_in_the_environment/links/569f935708ae4af52546b675.pdf

[15] IUCN (2017) *Primary Microplastics in the Oceans: a Global Evaluation of Sources.* https://portals.iucn.org/library/sites/library/files/documents/2017-002.pdf

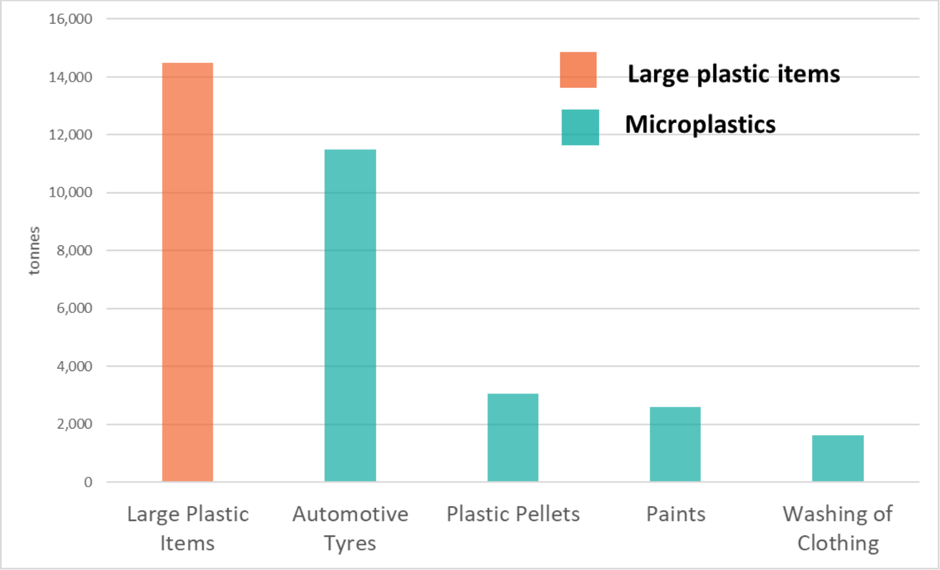
[16] Zubris, K.A.V., and Richards, B.K. (2005) Synthetic fibers as an indicator of land application of sludge, *Environmental Pollution*, Vol.138, No.2, pp.201–211

[17] http://wwf.panda.org/our_work/food/agriculture/impacts/soil_erosion/

[18] Plastics Europe (2016) *Plastics – the Facts 2016: An analysis of European plastics production, demand and waste data*, October 2016

[19] Eunomia Research & Consulting (2016) *Study to support the development of measures to combat a range of marine litter sources*, Report for European Commission DG Environment, 2016

Figure 1 – Estimates for Key Sources of Marine Plastic Pollution from the UK from land-based sources. Source: Forthcoming Eunomia report for Friends of the Earth.



3. How comprehensive is our knowledge about the scale of microplastic pollution and its effects? What should the research priorities be?

3.1. It is increasingly clear that microplastic pollution is pervasive across both terrestrial and aquatic environments, on and off-shore. Less clear, and in urgent need of research, includes:

3.1.1. How much microplastic pollution is already in the environment, the rate at which more is being added, and confirmation of what the main sources are. For example, the recent study of water courses near Manchester revealed far higher microplastic pollution and output to the sea than expected[20];

3.1.2. The pathways by which microplastics reach and travel through the environment, including through food chains;

3.1.3. Their impacts, including that of adsorbed and other associated chemicals, on wildlife. This is especially so with regard to multi-generational impacts.

3.2. The Welsh government should work with partners to fund research into the potential health impacts of exposure to microplastic and in particular nanoplastic pollution, including across multiple generations, and how to reduce exposure.

3.3. Urgent research is needed into alternatives to plastics, including business model as well as product design changes. This must evaluate the relative impacts of alternative materials so that we do not simply substitute one environmental and social material for another with potentially worse outcomes.

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[20] Hurley, R, Woodward, J & Rothwell, J (2018). Nature Geoscience volume 11, 251–257 . https://www.nature.com/articles/s41561-018-0080-1

4. What is currently being done to minimise the release of microplastics into the environment? What more can be done, and by whom, to address this issue within Wales?

4.1. The ban on microbeads in rinse-off products is welcome, but should be extended to cover all products for which plastic is added as an ingredient, whether or not in bead form.

4.2. Wales leads the UK and much of the world with its achievements and future targets for recycling and composting. However recycling can only play a limited role in ending plastic pollution.

4.3. Wales must focus on prevention of plastic pollution from the range of sources, emphazing reduced production and use of plastic. This includes bans on non-essential and easy-to-replace uses of plastic. Synthetic clothes makers must be required to attach filters to washing machines pre-sale to capture microfibres, and stop selling any but the least-polluting products.

4.4. Prevent the significant pollution caused by unmonitored combined sewage outflows (CSOs), the thousands of gates that are opened to bypass wastewater treatment plants during heavy rains.[21,22]

4.5. Require clearer labelling on products that contain plastic, such as cosmetics and synthetic clothing. This should include advice as to how to minimise plastic pollution from these products.

4.6. Legislate to class plastic as a pollutant so that public bodies can act and be held to account.

4.7. Friends of the Earth recommends the Welsh government adopt legislation that would include commitments to:

4.7.1. **Right now: begin the phase-out of unnecessary single-use plastics**: Plastic items that are unnecessary, easily replaceable or difficult to recycle – such as straws, coffee cups and stirrers - should be rapidly removed from circulation. Exceptions should be made for plastics that are essential for health and well-being, such as straws for people with disabilities;

4.7.2. **As soon as we can: end pollution from hard-to-replace plastics:** such as from the wear and tear of car tyres, synthetic clothes and paints, but with government support Wales' world-leading researchers and designers can plot a course to ending pollution from these too;

4.7.3. **Aim for near zero plastics pollution within twenty years:** This would align with the UK government's 25-Year Environment Plan which committed to eliminate 'avoidable' plastic by 2042, and should cover all significant sources of plastics pollution.

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[21] Water UK (2009) Combined Sewer Overflow Position Paper - Draft
[22] Marine Conservation Society (2011) Combined Sewage Overflow Position Paper

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30 September 2018

Dear Llyr,

Ahead of the forthcoming publication of the outline draft Budget 2019-20, I am writing to update you about the work to establish a shared understanding around a definition of prevention.

When I gave evidence to the Finance Committee during last year's Budget scrutiny, I said discussions were ongoing with our public and third sector partners to define preventative spend.

We have worked with a number of organisations, including Wales Council for Voluntary Action and the Future Generations Commissioner (FGC), to move this important agenda forward. The discussions culminated in a roundtable event in July, organised by the Commissioner's office and attended by Welsh Government officials, the third sector, Public Health Wales, the fire service and academics. It was constructive and has helped to shape our thinking.

We have now agreed a definition of prevention. I hope it will provide a useful framework, which allows an holistic evaluation of government expenditure:

Prevention is working in partnership to co-produce the best outcomes possible, utilising the strengths and assets people and places have to contribute. Breaking down into four levels, each level can reduce demand for the next:

- **Primary prevention** – building resilience – creating the conditions in which problems don't arise in the future. A universal approach.
- **Secondary prevention** – targeting action towards areas where there is a high risk of a problem occurring. A targeted approach which cements the principles of progressive universalism.*
- **Tertiary prevention** – intervening once there is a problem to stop it getting worse and prevent it reoccurring in the future. An intervention approach.
- **Acute spending** – spending, which acts to manage the impact of a strongly negative situation but does little or nothing to prevent problems occurring in the future. A remedial approach.

***Progressive universalism** is a determination to provide support for all, giving everyone and everything a voice and vested interest, but recognises more support will be required by those people or areas with greater needs.

We will use this definition to classify a spending area in each of the six Main Expenditure Groups (MEGs) in this budget round. An analysis of the results, which will be set out in the detailed draft Budget – published on 23 October – will provide a preliminary insight towards the proportion of spend in each category.

These findings will help to inform our thinking further and will provide a useful platform on which we can continue to build on in the future.

I look forward to working with the Finance Committee during its scrutiny of the draft Budget.

Best wishes,

Mark

Mark Drakeford AM/AC
Ysgrifennydd y Cabinet dros Gyllid
Cabinet Secretary for Finance

Agenda Item 7

By virtue of paragraph(s) vi of Standing Order 17.42

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