EEB and ClientEarth Submission to the call for evidence

GENERAL COMMENTS

Scope of the restriction

The EEB and ClientEarth are concerned that the ECHA may limit already the scope in the Annex XV proposal that it presents, given the call it has made to industry to submit information on the need for derogations during this call for evidence.

RAC and SEAC Committees have so far refused to broaden the scope of any restriction proposals, following indications from the ECHA Secretariat, although they do routinely narrow the scope of the proposed restrictions following industry claims. In the case that derogations are already included in the restriction proposal on microplastics to be submitted by ECHA, we are concerned that it would be very difficult to reject them during the actual opinion making process at ECHA's Committees, even if there is evidence provided during the public consultation that the need for such derogations is not properly justified or that the derogations would pose an "unacceptable risk" to the health of EU citizens or to the environment.

Further, we are concerned that ECHA would propose derogations or carve out of the scope certain uses on unjustified grounds. For example, ECHA seems to suggest in the Q&As[1], that the fact that a "risk cannot be demonstrated" for a specific use of microplastics would justify a derogation. However, when there is positive evidence showing an unacceptable risk arising in general from intentionally added microplastics, the existence of uncertainties, or lack of data, on the risk arising from a *specific application* of microplastics, is not an evidence of an absence of risk (or adequate control of the risk) for this specific application[2] ECHA needs to take into account the reminder given by the REACH review in relation to restrictions: the precautionary principle 'could be invoked by ECHA where there are indications of potential risks while the insufficiency of data, their inconclusive or imprecise nature makes it impossible to determine with sufficient certainty the risk in question'.[3] In the context of microplastics, for a derogation to be justified, the company would have to bring specific evidence proving that the risk is adequately controlled in its specific case.

Similarly, ECHA seems to consider that "*where there are no technically or economically feasible alternatives*" (Q&As)[1], a derogation is automatically justified. This interpretation of REACH is illegal. Article 68 and its reference to Annex XV do require to "take into account" the availability of alternatives. But, it absolutely does not exclude the adoption of a restriction when there is no alternative, so long as the evidence shows that the risk identified is not adequately controlled. The existence/absence of alternatives

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1 https://echa.europa.eu/documents/10162/09dbda4c-fcc9-4ede-0786-a13c6041ceec

2 See European Environment Agency, Late lessons from early warning (Volume I), chapter 5 p. 53, describing the "common fallacy" that "no evidence of harm" is the same as "evidence of no harm". This fallacy, according to Gee and Greenberg, "has inhibited the identification of many dangerous substances which were initially considered to be harmless ('false negatives')". It is surprising to see that ECHA, in 2018, still relies on this flawed reasoning.

3 See Annex 4 to Staff document p 111.

is simply one of the factors covered by the assessment. ECHA should be careful not to confuse the conditions for rejecting an authorisation under Article 60 with the conditions for adopting a restriction under Article 68. Moreover, by derogating uses or substances that seem to lack alternatives is disincentivising the development of new alternatives or the marketing or alternatives that may have not been considered by ECHA. This is against of the spirit of REACH that aims to promote substitution.

Overall, the way ECHA framed and presented this call for evidence raises questions as to ECHA's objectivity in implementing the REACH Regulation in the context of restriction. This is but one example of a more structural problem: ECHA's tendency to present itself as being at the service of industry.

Therefore, we ask ECHA to take this into consideration when drafting the proposal, and in case it finds out evidence pointing towards the need for a derogation, to ensure the inclusion in the Annex XV dossier all the related risk and socio-economic information, that the RAC and the SEAC may need in order to assess the need for these derogations, the subsequent uncertainties and costs of inaction. We ask ECHA to ensure that the Committees have the information and capacity to reject these derogations also in case the information provided through the public consultation demonstrates that there is no need for such a derogation. If a derogation is included before the Annex XV restriction proposal is submitted to RAC and SEAC, or if some uses are carved out of the scope of the restriction at this early stage, we are concerned that this will limit the possibility for third parties to convince RAC and SEAC during the public consultation that these derogations or the limited scope of the restriction are unjustified. If this concern is confirmed during the public consultation on the restriction proposal, it would mean that ECHA made the public consultation ineffective in breach of Article 69(6) of REACH.

Consideration of microplastics effects as non-threshold

The EEB and ClientEarth support the background document conclusion that the effects of microplastics to the aquatic environment should be considered as non-threshold: "In view of these considerations, though some effects and therefore possible impacts (risks) to the aquatic environment are expected, it is not possible at this stage to derive specific thresholds or establish a dose (concentration) response relationship" (AMEC Background document, page 78).

Furthermore, taking into account the high persistence of micro and nano plastics in the environment and their capacity to bio-accumulate, it is further justified that the risk assessment considers microplastics as non-threshold substances and follow a similar approach to restricting vPvB or PBT substances. Also some authors propose that microplastics themselves and some microplastic additives should be considered PBTs or even POPs:

Invited Commentary. Microplastics Are Not Important for the Cycling and Bioaccumulation of Organic Pollutants in the Oceans—but Should Microplastics Be Considered POPs Themselves? Rainer Lohmann. Integrated Environmental Assessment and Management — Volume 13, Number 3—pp. 460–465

> "There is strong evidence that microplastics are persistent, as a result of their industrial polymer properties and additives (Gewert et al. 2015), and that they undergo long-range transport, as documented by their widespread presence in remote oceans (Law et al. 2010; van Sebille et al. 2015). Several ecotoxicological studies highlight adverse effects, although these experiments are often performed at unrealistically high doses of microplastic exposure. The classical concept of bioaccumulation and biomagnification on a molecular level is not met, but there is evidence that microplastics are present in top predators and are transferred up the food chain."

Some studies like the one above also consider the concern of high mobility rates of microplastics, another aspect that would contribute to its consideration as substance of high concern.

Emma L. Teuten, et al. **Transport and release of chemicals from plastics to the environment and to wildlife.** Phil. Trans. R. Soc. B 2009 364 2027-2045; DOI: 10.1098/rstb.2008.0284. Published 14 June 2009

> "Plastics debris in the marine environment, including resin pellets, fragments and microscopic plastic fragments, contain organic contaminants, including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons, petroleum hydrocarbons, organochlorine pesticides (2,2′-bis(*p*-chlorophenyl)-1,1,1-trichloroethane, hexachlorinated hexanes), polybrominated diphenylethers, alkylphenols and bisphenol A, at concentrations from sub ng g^{-1} to µg g^{-1}. Some of these compounds are added during plastics manufacture, while others adsorb from the surrounding seawater. Concentrations of hydrophobic contaminants adsorbed on plastics showed distinct spatial variations reflecting global pollution patterns. Model calculations and experimental observations consistently show that polyethylene accumulates more organic contaminants than other plastics such as polypropylene and polyvinyl chloride. Both a mathematical model using equilibrium partitioning and experimental data have demonstrated the transfer of contaminants from plastic to organisms. A feeding experiment indicated that PCBs could transfer from contaminated plastics to streaked shearwater chicks. Plasticizers, other plastics additives and constitutional monomers also present potential threats in terrestrial environments because they can leach from waste disposal sites into groundwater and/or surface waters. Leaching and degradation of plasticizers and polymers are complex phenomena dependent on environmental conditions in the landfill and the chemical properties of each additive. Bisphenol A concentrations in leachates from municipal waste disposal sites in tropical Asia ranged from sub µg l^{-1} to mg l^{-1} and were correlated with the level of economic development."

Tamara S. Galloway in book: **Marine Anthropogenic Litter, Edition: 1, Chapter: Micro and nanoplastics and human health**, Springer Open, Editors: Melanie Bergmann, lars Gutow, Michael Klages, pp.343-366, July 2015. https://link.springer.com/content/pdf/10.1007%2F978-3-319-16510-3_13.pdf

> "By 2050, however, it is anticipated that an extra 33 billion tonnes of plastic will be added to the planet. Given that most currently used plastic polymers are highly resistant to degradation, this influx of persistent, complex materials is a risk to human and environmental health. Continuous daily interaction with plastic items allows oral, dermal and inhalation exposure to chemical components, leading to the widespread presence in the human body of chemicals associated with plastics. Indiscriminate disposal places a huge burden on waste management systems, allowing plastic wastes to infiltrate ecosystems, with the potential to contaminate the food chain. Of particular concern has been the reported presence of microscopic plastic debris, or microplastics (debris ≤ 1 mm in size), in aquatic, terrestrial and marine habitats. Yet, the potential for microplastics and nanoplastics of environmental origin to cause harm to human health remains understudied. In this article, some of the most widely encountered plastics in everyday use are identified and their potential hazards listed. Different routes of exposure to human populations, both of plastic additives, microplastics and nanoplastics from food items and from discarded debris are discussed. Risks associated with plastics and additives considered to be of most concern for human health are identified. Finally, some recent developments in delivering a new generation of safer, more sustainable polymers are considered."

Microplastics have been found in multiple studies to transport persistent organic pollutants (POPs) into organisms (in particular, polyethylene/polyester):

Bakir, A., Rowland, S. J., & Thompson, R. C. (2012). **Competitive sorption of persistent organic pollutants onto microplastics in the marine environment.** Marine pollution bulletin, 64(12), 2782-2789.

Teuten, E. L., Saquing, J. M., Knappe, D. R., Barlaz, M. A., Jonsson, S., Björn, A., ... & Takada, H. (2009). **Transport and release of chemicals from plastics to the environment and to wildlife**. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 2027-2045.

A past study by Connell, R. et al (1988) also found a positive correlation between polychlorinated biphenyls (a POP) and plastic ingestion (although the plastic studied was not microscopic).

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

The potential for microplastics to transport POPs into the food chain adds an entire category to potential impacts of microplastics as POPs have a wide array of impacts on organisms. If microplastics significantly raise the rate of POP accumulation in organisms naturally, the presence of microplastics would have complex impacts that may be quite severe. A study by Frias, J. et al. (2010) found mostly fibrous microplastic in samples of the Portuguese coast that was contaminated with POPs (including polycyclic aromatic hydrocarbon, polychlorinated biphenyls, and DDTs).

Frias, J. P. G. L., Sobral, P., & Ferreira, A. M. (2010). **Organic pollutants in microplastics from two beaches of the Portuguese coast**. Marine Pollution Bulletin, 60(11), 1988-1992.

Sand also provides another pathway for pollutants and a study by Brown et al. (2013) found that the amount of additives transferred by microplastic (PVC) was not significantly greater than sand.

Browne, M. A., Niven, S. J., Galloway, T. S., Rowland, S. J., & Thompson, R. C. (2013). **Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity**. Current Biology, 23(23), 2388-2392.

This indicates that the pollutant transfer impacts of microplastic may be variable depending on environment.[4]

As remarked by Ms Galloway, Gallo et al, Talsness et al and Teuten et al and others, another aspect to be considered is the presence of plastics additives of concern to human health. Plastics can contain complex mixtures of additives to enhance their physical properties, which can leach from the polymer into the surrounding milieu. These additives are known for its endocrine disrupting properties, as for example phthalates, bisphenol A, brominated flame retardants, triclosan, bisphenone and organotins.

The potential migration of polymer constituents and additives into food and drinks is considered to be a major route of exposure of the human population. The European Food Standards Agency has a total migration limit of 10 mg/dm^2 for additives within plastics intended for packaging use, with a more stringent migration limit of 0.01 mg/kg for certain chemicals of concern (Commission Directive 2007/19/CE that modifies Directive 2002/72/CE). This means that for an average 60 kg adult who consumes 3 kg of foods and liquids per day, exposures to individual substances from food packaging could be up to 250 µg/kg body weight per day (Muncke 2011).

Frederic Gallo, Cristina Fossi, Roland Weber, David Santillo, Joao Sousa, Imogen Ingram, Angel Nadal and Dolores Romano. Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. Environmental Sciences Europe December 2018, 30:13 https://link.springer.com/article/10.1186/s12302-018-0139-z:

> "Some plastic additives with endocrine disruptive properties which might not pass some of the POPs screening criteria such as persistence in water in standard laboratory conditions, are expected to have longer half-life in the plastic due to the protection (or molecular encapsulation) within the polymer matrix, and may have even longer half-life in the marine environment, due to its physical and chemical properties such as lower temperatures, lower oxygen levels, salinity, pH, and lower levels of light in water column and sea floor and sediments, i.e. theoretically "non-persistent" chemical additives or trace monomers in plastics (such as alkylphenols, phthalates, BPA) have been

[4] https://brenmicroplastics.weebly.com/impacts.html

detected in high concentrations in floating polyethylene and polypropylene plastic—the most widely used in packaging—in open oceans [18, 58, 60, 69]."

Chris E. Talsness, Anderson J. M. Andrade, Sergio N. Kuriyama, Julia A. Taylor, Frederick S. vom Saal. **Components of plastic: experimental studies in animals and relevance for human health**.
Phil. Trans. R. Soc. B 2009 364 2079-2096; DOI: 10.1098/rstb.2008.0281. Published 14 June 2009

> "Components used in plastics, such as phthalates, bisphenol A (BPA), polybrominated diphenyl ethers (PBDE) and tetrabromobisphenol A (TBBPA), are detected in humans. In addition to their utility in plastics, an inadvertent characteristic of these chemicals is the ability to alter the endocrine system. Phthalates function as anti-androgens while the main action attributed to BPA is oestrogen-like activity. PBDE and TBBPA have been shown to disrupt thyroid hormone homeostasis while PBDEs also exhibit anti-androgen action. Experimental investigations in animals indicate a wide variety of effects associated with exposure to these compounds, causing concern regarding potential risk to human health. For example, the spectrum of effects following perinatal exposure of male rats to phthalates has remarkable similarities to the testicular dysgenesis syndrome in humans. Concentrations of BPA in the foetal mouse within the range of unconjugated BPA levels observed in human foetal blood have produced effects in animal experiments. Finally, thyroid hormones are essential for normal neurological development and reproductive function. Human body burdens of these chemicals are detected with high prevalence, and concentrations in young children, a group particularly sensitive to exogenous insults, are typically higher, indicating the need to decrease exposure to these compounds."

The risk assessment shall take into consideration the wide dispersive exposure to small/nano particles

The uncertainties regarding the risk assessment approach included in the background document (AMEC, page 48) state that "Concentrations based on particle numbers require assumptions to be made over the particle size. The current values reported assume a particle size of 200 µm. However, assuming a smaller particle size (e.g. 2 µm) would increase the predicted concentrations by a factor of up to around 1×10^{6} , increasing the particle size (e.g. to 100 µm) would decrease the predicted concentrations by a factor of around 200."

Microplastics could contribute up to 30% of the 'plastic soup' polluting the world's oceans and – in many developed countries – are a bigger source of marine plastic pollution than the more visible larger pieces of marine litter, according to a 2017 IUCN report.

R. C. Thompson, C. J. Moore, F. S. vom Saal and S. H. Swan. Theme Issue **'Plastics, the environment and human health**' 27 July 2009; volume 364, issue 1526

> "Within the last few decades, plastics have revolutionized our daily lives. Globally we use in excess of 260 million tonnes of plastic per annum, accounting for approximately 8 per cent of world oil production. "

The following article provides evidence on the need to consider the high exposure to nanoparticles:

Messika Revel, Amélie Châtel and Catherine Mouneyrac. **Micro(nano)plastics: A threat to human health?** Environmental Science & Health 2018, 1:17–23. https://doi.org/10.1016/j.coesh.2017.10.003
https://www.sciencedirect.com/science/article/pii/S2468584417300235

> "This paper provides a review on routes of human exposure and potential effects of MPs and NPs to human health. MPs/NPs could potentially induce: physical damages through particles itself, and biological stress through Mps/Nps alone or leaching of additives (inorganic and organic). Future

research should evaluate trophic transfer of MPs/NPs with their associated chemicals through the marine food web."

A new article by Gallo et al. Environ Sci Eur (2018) 30:13 (full reference above) provide further evidence on the potential of nanoplastics to increase the exposure to additives and other chemicals:

"In nanoplastics, the high surface area may present exceptionally strong sorption affinities for pollutants, thus changing the exposure and risk to these chemicals [65], and further increasing their significance as contributors to overall chemical exposure. In this regard, Koelmans et al. [66] affirm that: "because of the surface effect, it may be possible that nanoplastics retain organic toxic chemicals or heavy metals at higher concentrations than microplastics, thus leading to a fugacity gradient to organism tissue once ingested. If nanoplastics are capable of permeating membranes, passing cell walls, translocate and/or reside in epithelial tissues for prolonged times, the combination of particle and chemical toxicity may yield unforeseen risks" Velzeboer et al. [65] affirm that: "Nano-plastics have been shown to pass through the chorion of fish eggs and have been shown to move directly from the digestive tract of mussels into their circulatory system. This implies that occurrence of HOC contaminated nanoplastics in the environment may potentially enhance uptake".

In 2011 Mark Browne and colleagues published Accumulation of microplastic on shorelines worldwide: sources and sinks, showing global pollution by microfibres from textiles such as polyester, nylon and acrylic, coming from washing machines, drains and sewers.

Browne MA, Crump P, Niven SJ, Teuten E, Tonkin A, Galloway T, Thompson R. **Accumulation of microplastic on shorelines woldwide: sources and sinks.** Environ Sci Technol. 2011 Nov 1;45(21):9175-9. doi: 10.1021/es201811s. Epub 2011 Oct 4.

"Plastic debris <1 mm (defined here as microplastic) is accumulating in marine habitats. Ingestion of microplastic provides a potential pathway for the transfer of pollutants, monomers, and plastic-additives to organisms with uncertain consequences for their health. Here, we show that microplastic contaminates the shorelines at 18 sites worldwide representing six continents from the poles to the equator, with more material in densely populated areas, but no clear relationship between the abundance of miocroplastics and the mean size-distribution of natural particulates. An important source of microplastic appears to be through sewage contaminated by fibers from washing clothes. Forensic evaluation of microplastic from sediments showed that the proportions of polyester and acrylic fibers used in clothing resembled those found in habitats that receive sewage-discharges and sewage-effluent itself. Experiments sampling wastewater from domestic washing machines demonstrated that a single garment can produce >1900 fibers per wash. This suggests that a large proportion of microplastic fibers found in the marine environment may be derived from sewage as a consequence of washing of clothes. As the human population grows and people use more synthetic textiles, contamination of habitats and animals by microplastic is likely to increase."

New evidence on environmental concentrations of microplastics reported in the literature:

Rachel Hurley, Jamie Woodward & James J. Rothwell. **Microplastic contamination of river beds significantly reduced by catchment-wide flooding**. Nature Geosciencevolume 11, pages251–257 (2018). doi:10.1038/s41561-018-0080-1"

"Microplastic contamination of the oceans is one of the world's most pressing environmental concerns. The terrestrial component of the global microplastic budget is not well understood because sources, stores and fluxes are poorly quantified. We report catchment-wide patterns of microplastic contamination, classified by type, size and density, in channel bed sediments at 40 sites across urban, suburban and rural river catchments in northwest England. Microplastic

> contamination was pervasive on all river channel beds. **We found multiple urban contamination hotspots with a maximum microplastic concentration of approximately 517,000 particles m^{-2}**."

Alina M. Wieczorek, Liam Morrison, Peter L. Croot, A. Louise Allcock, Eoin MacLoughlin, Olivier Savard, Hannah Brownlow and Thomas K. Doyle. **Frequency of Microplastics in Mesopelagic Fishes from the Northwest Atlantic**. Front. Mar. Sci., 19 February 2018. https://doi.org/10.3389/fmars.2018.00039

> "Fish specimens were collected from depth (300–600 m) in a warm-core eddy located in the Northwest Atlantic, 1,200 km due east of Newfoundland during April and May 2015. In total, 233 fish gut contents from seven different species of mesopelagic fish were examined. Seventy-three percent of all fish contained plastics in their gut contents with Gonostoma denudatum having the highest ingestion rate (100%) followed by Serrivomer beanii (93%) and Lampanyctus macdonaldi (75%). Overall, we found a much higher occurrence of microplastic fragments, mainly polyethylene fibres, in the gut contents of mesopelagic fish than previously reported. Stomach fullness, species and the depth at which fish were caught at, were found to have no effect on the amount of microplastics found in the gut contents. However, these plastics were similar to those sampled from the surface water."

Johnny Gasperi, Stephanie L. Wright, Rachid Dris, France Collard, Corinne Mandin, Mohamed Guerrouache, Valérie Langlois, Frank J. Kelly and Bruno Tassin. **Microplastics in air: Are we breathing it** in? Environmental Science & Health; 2018, 1:1–5

> "The annual production of plastic textile fibers has increased by more than 6% per year, reaching 60 million metric tons, about 16% of world plastic production. The degradation of these fibers produces fibrous microplastics (MPs). Such MPs have been observed in atmospheric fallouts, as well as in indoor and outdoor environments. Some fibrous MPs may be inhaled. Most of them are likely to be subjected to mucociliary clearance; however, some may persist in the lung causing localized biological responses, including inflammation, especially in individuals with compromised clearance mechanisms. Associated contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs) could desorb and lead to genotoxicity while the plastic itself and its additives (dyes, plasticizers) could lead to health effects including reproductive toxicity, carcinogenicity and mutagenicity."

Therese M.Karlsson, LarsArneborg, GöranBroström, Bethanie Carney Almroth, Lena Gipperth, Martin Hassellöva. **The unaccountability case of plastic pellet pollution.** Marine Pollution Bulletin, Volume 129, Issue 1, April 2018, Pages 52-60. https://doi.org/10.1016/j.marpolbul.2018.01.041

Ali Karami, Abolfazl Golieskardi, Cheng Keong Choo, Vincent Larat, Tamara S. Galloway & Babak Salamatinia. **The presence of microplastics in commercial salts from different countries**. Scientific Reports volume 7, Article number: 46173 (2017). doi:10.1038/srep46173

Christian, Scherer; Annkatrin, Weber; Scott, Lambert; Wagner, Martin. **Interactions of Microplastics with Freshwater Biota. I: Freshwater microplastics: Emerging Environmental Contaminants?**. Springer 2018 ISBN 978-3-319-61614-8. s. 153-180

Wagner, Martin; Scott, Lambert. **Freshwater microplastics: Emerging Environmental Contaminants?**. Springer 2018 (ISBN 978-3-319-61614-8) 308 s. The Handbook of Environmental Chemistry(58)

Lambert, Scott; Wagner, Martin. **Environmental performance of bio-based and biodegradable plastics: The road ahead.** Chemical Society Reviews 2017; Volum 46.(22) s. 6855-6871

Scherer, Christian; Brennholt, Nicole; Reifferscheid, Georg; Wagner, Martin. **Feeding type and development drive the ingestion of microplastics by freshwater invertebrates.** Scientific Reports 2017; Volum 7.(1) s. 1-9

Montserrat Filella, Andrew Turner. **Observational Study Unveils the Extensive Presence of Hazardous Elements in Beached Plastics from Lake Geneva**. Frontiers in Environmental Science, 2018; 6 DOI: 10.3389/fenvs.2018.00001

SPECIFIC COMMENTS

Definition of microplastics

The EEB and ClientEarth consider that the Annex XV restriction dossier to be prepared by ECHA should include a broad definition that ensures that all intentionally used or intentionally released microplastics are covered, independent of the kind of polymer or solubility stage.

Therefore, we support that the definition should include any polymer, including liquid polymers, that can become a source of microplastics during its use or release.

We also support the inclusion under the definition of compostable bioplastics or plastics labelled as 'biodegradable in the environment' as these plastics may not degrade in marine conditions, "where parameters such as temperature, oxygen, and salinity are very different that those expected in a composting process, and so they have equivalent properties in the marine environment in this regard as persistent plastics." Frederic Gallo, Cristina Fossi, Roland Weber, David Santillo, Joao Sousa, Imogen Ingram, Angel Nadal and Dolores Romano. Marine litter plastics and microplastics and their toxic chemicals components: the need for urgent preventive measures. Environmental Sciences Europe December 2018, 30:13 https://link.springer.com/article/10.1186/s12302-018-0139-z

Further information: Briefing Banning the use of microplastic ingredients. Environmental Investigation Agency, Fauna & Flora International, Marine Conservation Society, Seas at Risk and Surfrider Foundation Europe.

Information on other socio-economic impacts on society

Microplastic pollution is not only an aesthetic or wildlife-harming problem but potentially an economic and sustainability issue. If it also turns out for example that new and hazardous chemical reactions take place on the surface of micro plastics, or they otherwise affect human health. The UK CIWEM, the Chartered Institution of Water and Environmental Management recently published a report entitled 'Addicted to Plastic' which pointed out that half of all microplastic pollution remains on land, and large amounts of microplastics removed at sewage treatment works end up back on farmland as they are spread in fertiliser 'sludge'.

Micro- and Nano-plastics risks to Human Health and development of potential alternatives

Micro and nano-plastics can be introduced into human bodies sometimes for therapeutic purposes, such as carrying drugs. Different routes of exposure to human populations, both of plastic additives, micro- and nanoplastics from food items and from discarded debris are discussed in relation to the existing literature for nanomedicines and nanocomposite packaging materials, for which an increasing body of knowledge exists.

Tamara S. Galloway concludes in her book **Marine Anthropogenic Litter, Edition: 1, Chapter: Micro and nanoplastics and human health**, Springer Open, Editors: Melanie Bergmann, lars Gutow, Michael Klages, pp.343-366, July 2015. https://link.springer.com/content/pdf/10.1007%2F978-3-319-16510-3_13.pdf

> "Given that most currently used plastic polymers are highly resistant to degradation, this influx of persistent, complex materials is a risk to human and environmental health. Continuous daily

> interaction with plastic items allows oral, dermal and inhalation exposure to chemical components, leading to the widespread presence in the human body of chemicals associated with plastics. Indiscriminate disposal places a huge burden on waste management systems, allowing plastic wastes to infiltrate ecosystems, with the potential to contaminate the food chain… Yet, the potential for microplastics and nanoplastics of environmental origin to cause harm to human health remains understudied. In this article, some of the most widely encountered plastics in everyday use are identified and their potential hazards listed. Different routes of exposure to human populations, both of plastic additives, microplastics and nanoplastics from food items and from discarded debris are discussed. Risks associated with plastics and additives considered to be of most concern for human health are identified. Finally, some recent developments in delivering a new generation of safer, more sustainable polymers are considered."

The potential migration of polymer constituents and additives into food and drinks is considered to be a major route of exposure.

R. C. Thompson, C. J. Moore, F. S. vom Saal and S. H. Swan. Theme Issue **'Plastics, the environment and human health**' 27 July 2009; volume 364, issue 1526

> "Within the last few decades, plastics have revolutionized our daily lives. Globally we use in excess of 260 million tonnes of plastic per annum, accounting for approximately 8 per cent of world oil production. At the same time, we examine the environmental consequences resulting from the accumulation of waste plastic, the effects of plastic debris on wildlife and concerns for human health that arise from the production, usage and disposal of plastics. Finally, we consider some possible solutions to these problems together with the research and policy priorities necessary for their implementation."

A study by Browne et al. (2013) did find indications of significant impact by microplastic (PVC) consumption in lugworms where oxidative stress was increased by about 30%.

Browne, M. A., Niven, S. J., Galloway, T. S., Rowland, S. J., & Thompson, R. C. (2013). **Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity**. *Current Biology*, *23*(23), 2388-2392.

The fourth edition of the Textile Exchange Preferred Fiber & Materials (PFM) Market Report presents several alternatives to micro fibres in the textile sector.

The CIWEM paper says Circular Economy measures 'should include improved product design and substitution, extended producer responsibility and deposit return schemes'.