

## COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD, CONSUMER PRODUCTS AND THE ENVIRONMENT (COT)

### Overarching statement on the potential risks from exposure to microplastics

#### Background

1. Plastic pollution has been widely recognised as a global environmental problem (Villarrubia-Gómez *et al.*, 2018). The adverse effects of plastic litter have been widely documented for marine animals (*e.g.* entanglement, ingestion and lacerations), however, the potential risks from exposure to smaller plastic particles *i.e.* micro- and nanoplastics in humans are yet to be fully understood.

#### Scope and purpose

2. As part of horizon scanning, the COT identified the potential risks from microplastics as a topic it should consider. Upon review of the literature, it was decided that nanoplastics should also be included. An initial scoping paper was presented to the COT in October 2019 (TOX/2019/62)<sup>1</sup>, since then the topic and additional information has been discussed several times by COT with the final substantive discussion in September 2020.

3. The purpose of this overarching statement is to bring together these discussions, summarise the COT conclusions reached to date and provide a high-level overview of the current state of knowledge, data gaps and research needs with regards to this topic.

4. Future sub-statements which will consider in detail the potential toxicological risks of exposure from microplastics *via* the oral and inhalation routes are intended to provide supplementary material for this overarching statement. The Committee discuss a review of the potential risks from oral exposure of microplastics (resulting from their presence in food and bottled drinks). A review of the potential risks of microplastics *via* the inhalation route will be produced jointly with the Committee of Medical Effects of Air Pollutants (COMEAP) Secretariat at Public Health England. The need for additional reviews of other significant routes of exposure will also be considered.

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<sup>1</sup> TOX/2019/62 is available on the [COT website](#).

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## Definitions

5. For the purposes of this overarching statement, microplastics and nanoplastics have been differentiated solely on the basis of size without consideration of properties characteristic of the nanoscale.

### *Microplastics*

6. Microplastics are defined as synthetic particles or heavily modified natural particles with a high polymer content that are submicron in size (0.1 to 5,000 µm or micrometres).

7. It should be noted that currently there is no internationally agreed definition of a microplastic, however, publications by Verschoor (2015) and Hartmann *et al.*, (2015) have proposed criteria and considerations to be included in the definition of microplastics. In Europe, the European Chemicals Agency (ECHA) has proposed a regulatory definition for a microplastic under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation (ECHA, 2019). In the US, the California Water Boards also recently published a proposed definition of microplastics in drinking water in March 2020<sup>2</sup>.

8. Verschoor (2015) included 5 major properties to be considered including the chemical composition, physical state, particle size, solubility in water and degradability. On a similar note Hartmann *et al.*, (2015) proposed seven criteria; chemical composition, solid state, solubility, size, shape and structure, colour and origin (*i.e.* primary or secondary, as discussed in the following paragraphs).

9. In Europe, the ECHA proposed definition for a microplastic is a “material consisting of solid polymer-containing particles, to which additives or other substance may have been added, and where  $\geq 1\%$  w/w have (i) all dimensions  $1 \text{ nm} \leq x \leq 5 \text{ mm}$  or (ii) for fibres, a length of  $3 \text{ nm} \leq x \leq 15 \text{ mm}$  and length to diameter ratio of  $>3$ . Polymers that occur in nature that have not been chemically modified (other than by hydrolysis) are excluded, as are polymers that are (bio)degradable.” (ECHA, 2019).

10. The current adopted definition of microplastics in drinking water by the California Water Boards is: “Microplastics in drinking water are defined as solid polymeric materials to which chemical additives or other substances may have been added, which are particles which have at least two dimensions that are greater than 1 and less than 5,000 µm. Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded.” (California Water Boards, 2020).

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<sup>2</sup> Further information on the California Water Boards activity on this topic are available on the [California Water Boards website](#).

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### *Nanoplastics*

11. Nanoplastics measure from 1 nm to 0.1  $\mu\text{m}$ . It is a general term based on the physical properties for a variety of chemical compositions. There is currently no further proposed definition.
12. A number of documents have assessed the risks of nanomaterials and provided guidance on their assessment, which would also apply to nanoplastics. For example, the European Food Safety Authority (EFSA) Scientific Committee published an opinion on the potential risks arising from nanoscience and nanotechnologies on food and feed safety in 2009 (EFSA, 2009). This opinion did not intend to provide any definitions; however, the term nanoscale refers to a dimension of the order of 100 nm and below. Engineered nanomaterial was described as any material that is deliberately created such that it is composed of discrete functional and structural parts, either internally or at the surface, many of which will have one or more dimensions of the order of 100 nm or less.
13. The EFSA Scientific Committee recommended that the addition of other metrics (*i.e.* specific surface area which is independent of the agglomeration status of particles) should be included into the current definition of nanoscale materials (EFSA, 2009).
14. In 2011, the EFSA published a guidance document on how EFSA's Panels should assess potential risks related to certain food-related uses of nanotechnology. New guidance on assessing the safety for humans and animals of nanoscience and nanotechnology applications in the food and feed chain was published in 2018 (EFSA, 2018).
15. The EFSA 2018 guidance was said to be applicable for: a material that meets the criteria for an engineered nanomaterial, as outlined in Novel Food Regulation (EU) No 2015/2283<sup>3</sup> and Regulation (EU) No 1169/2011<sup>4</sup> (*i.e.* have particle sizes in the defined nanoscale; 1-100 nm), a material that contains particles having a size above 100 nm which could retain properties that are characteristic of the nanoscale, a material that is not engineered as nanomaterial but contains a fraction of particles (<50% in the number-size distribution) with one or more external dimensions in the size range 1-100 nm, a nanomaterial having the same elemental composition but that occurs in different morphological shapes, sizes, crystalline forms and/or surface properties, and a nanoscale entity that is made or natural materials.
16. In July 2020, EFSA held a publication consultation on the draft EFSA Guidance on technical requirements for regulated food and feed product applications to establish the presence of small particles including nanoparticles<sup>5</sup>. The draft guidance outlines appraisal criteria grouped in three sections, to confirm whether or not the conventional risk assessment should be complemented with nano-specific considerations.

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<sup>3</sup> The Novel Food Regulation can be found in the [EUR-Lex website](#).

<sup>4</sup> Regulation (EU) No. 1169/2011 can be found in the [EUR-Lex website](#).

<sup>5</sup> Further details on the public consultation are available on the [EFSA website](#).

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17. The first group addresses solubility and dissolution rate as key physicochemical properties to assess whether consumers will be exposed to particles. The second group establishes the information requirements for assessing whether the conventional material contains a fraction or consists of small particles, and its characterisation. The third group describes the information to be presented for existing safety studies to demonstrate that the fraction of small particles, including those at the nanoscale, has been properly evaluated. Post-finalisation, this guidance was to complement the EFSA 2018 guidance (as described above) (EFSA, 2020).

### *Types*

18. There are two major types of microplastics. Firstly, those that are deliberately manufactured to be in the size range of 0.1 to 5,000 µm called primary microplastics, which are intentionally used in personal care products (such as microbeads) or for various industrial applications. Secondary microplastics can be formed in the environment due to fragmentation of larger pieces of plastic (e.g. toys, plastic bags, food contact materials, polymer coatings, for example on fruit) caused by a culmination of physical, biological and photochemical degradation termed; microplastic particles (MPPs). MPPs can be further degraded to form nanoplastics which are less than 0.1 µm in length.

19. Besides the types (and sources) mentioned above, within the scientific field there is some debate as to whether rubber tyre particles should be considered microplastics. Tyres were initially made of natural rubber from; the Brazilian rubber tree (*Hevea brasiliensis*), however, currently tyres are synthesised from a mixture of natural and synthetic materials. Synthetic rubbers are made from petroleum and are functionalised with the addition of; sulphur (1-4%), zinc oxide (1%), carbon black/silica (22-40%) and oil (Kole *et al.*, 2017).

20. Car tyres release wear particles through mechanical abrasion, resulting from the contact between the road surface and the tyre. The amount and particle size are dependent on several factors such as; climate (temperature), composition and structure of the tyre, tyre age, road surface, driving speed and style, and nature of the contact. As such, tyre wear particles can be described as another environmental source of microplastics (Baensch-Baltruschat *et al.*, 2020) (Kole *et al.*, 2017).

### *Characteristics*

#### Chemical composition

21. The chemical composition of microplastics can vary. Some can be made from single monomer repeats (*i.e.* polymers) such as polyethylene (PE) and polypropylene (PP) which are common in food packaging applications, and some are made from two monomers (*i.e.* co-polymers) for example styrene-butadiene.

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22. The composition can also vary based on the addition of other filler compounds. For example, additives that are required to preserve the stability of the polymer, impurities deriving from the manufacturing process, and the potential presence of unreacted monomers. Furthermore, substances may also be added to improve the functionality of the polymer including pigments, lubricants, thickeners, anti-static agents, anti-fogging agents, nucleating agents and flame retardants.

### *Sources*

23. Both nano- and microplastics (NMPs) are persistent environmental contaminants and have been detected in both the aquatic (*e.g.* oceans, freshwater rivers and lakes) and terrestrial (*e.g.* landfills, agricultural land from utilisation of plastic mulch, wastewater, sewage sludge, compost and anaerobic digestate) environments, often far removed from the point of manufacture or use of the original plastic materials. Due to their minute size (*i.e.* lighter mass), their presence in the air has also been detected (Gasperi *et al.*, 2018).

24. Due to their widespread status in the environment, microplastics have been also detected in food (*e.g.* seafoods, beer, salt and honey, tea, vegetables) and drinks (*e.g.* bottled water, milk, soft drinks) (Touissant *et al.*, 2019).

25. Plastics for use in a medical setting can also degrade to form NMPs. This includes wear particles from joints (*e.g.* polyethylene for hip prostheses (Merola & Affatato, 2019)) and biodegradable sutures. Note that these sources do not result from environmental exposures, as they are produced *in situ* in the body and remain in the affected area (*e.g.* joints) and/or further degrade there.

### *Physicochemical properties*

26. Due to the varying chemical composition and physicochemical properties of NMPs, there are currently limited analytical methods to detect and quantify their presence in various matrices. Currently, those applied include; Fourier-transform infrared spectroscopy (FT-IR), Nile Red staining techniques, Micro-Raman spectroscopy, quantitative <sup>1</sup>H nuclear magnetic resonance spectroscopy (qNMR) (Peez *et al.*, 2019) and mass-spectroscopy, however, each of these methods have their own associated limitations (Nguyen *et al.*, 2019).

27. Additionally, there are neither standardised testing protocols for different matrices (*i.e.* air, soil, food and water), nor standard reference materials. No single technique is suitable for all plastic types and for all particle sizes or shapes, and so the utilization of either a suite of methods or generation of new techniques may be necessary.

28. Comparison and replication of studies can be difficult due to differences in sampling, extraction, purification and analytical methods for enumerating and characterising microplastics. These methods are not yet standardized or subject to interlaboratory validation. Contamination with airborne microplastics or cross-

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contamination of samples pose as an issue, so control samples may be difficult to ascertain.

29. Most studies have performed tests on pristine particles; therefore, it is important to consider inter-variability of samples and batches. It is also important to recognise that pristine particles may not be representative of particles present in the environment as, for example, they have not undergone degradative processes in the environment.

#### Physical properties

30. As mentioned in earlier paragraphs, NMPs can differ in their shape (*e.g.* spherical, granules, fragments, fibres, spheroids, pellets, flakes and beads) size (*e.g.* nano-, micro-, macro), density, colour *etc.* The consideration of physical properties during hazard and/or risk assessment of plastic particles is important because their interactions with biological systems can vary with differences in size and shapes for particles with the same chemical composition.

31. Differences in physical properties for morphologies of tyre materials can also vary under various sampling conditions. Those collected from road runoff and shredded tyres have elongated shapes, whilst samples generated from road simulator systems in laboratories range from jagged, droplets, granules, warped, porous, irregular, and near spherical (Wagner *et al.*, 2018). As for the size distribution range of tyre wear and tear particles, a review by Kole *et al.*, (2017) revealed that this could be from 6-350,000 nm, the wide range which was attributed to the use of different size metrics.

#### Chemical properties

32. A particle's chemical properties such as charge or zeta potential (when particles are immersed in a conduction liquid *e.g.* water) are dependent on its chemical composition.

33. A particle's properties can also be influenced and changed by its surface chemistry. Each particle could have its own unique corona consisting of proteins adsorbed from plasma and/or intracellular fluid, adsorbed chemicals from the environment (*e.g.* other persistent organic pollutants, pharmaceutical compounds, metals) or microbiological organisms.

34. The physicochemical properties of microplastics can change over their life cycle and can also affect each other. For example, physical degradation resulting in the formation of nano-sized plastic particles and/or plastic particles with different shapes can generate a higher number of particles and as such gives rise to a larger total surface area and higher particle number which in turn affects the concentration. The weathering process can change the surface chemistry and size of microplastics, and chemical migration from the MPPs into the surrounding medium results in altered stability which in turn changes the physical degradation processes.

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## Hazard identification

35. There are three potential hazards with microplastics which are dependent on the particles' chemical composition and therefore their physicochemical properties these are: physical (e.g. gut blockage, as observed in aquatic and avian species), chemical (unbound monomers, additives, sorbed chemicals from the environment) and the presence of biofilms (attachment and colonisation of microorganisms on the plastics).

36. Due to the small size of NMPs, uptake across the gastrointestinal tract (GIT) and uptake into internal tissues is possible and thus can have both local and systemic implications. Particles <50 µm can be absorbed from the gut *via* gaps and by phagocytic and endocytic pathways but only those of <1-2 µm in size are able to cross cell membranes of internal organs.

37. In terms of microplastic fibres/airborne MPPs – their particulate properties must be characterised as long-term exposures could lead to chronic bronchitis and/or other respiratory diseases. The Committee previously reviewed the studies from Pimentel *et al.*, (1975), Hillerdal *et al.*, (1988) and Pauly *et al.*, (1998), whom studied the *in vivo* effects of occupational exposure to synthetic fibres.

38. The UK FSA is currently performing a critical literature review on the microbiological colonisation of micro- and nanoplastics and their significance to the food chain (FS307021)<sup>6</sup>, the project is scheduled for completion in early 2021. The critical review is expected to present an overview of NMPs in the environment, the interaction of NMP and micro-organisms, the identification of key pathways these microbiologically contaminated materials could enter the food chain from environmental sources (e.g. water, soil, and air), and the risk(s) that these might pose to the consumer (FSA, 2020).

## Sources of exposure

39. This section will be divided into two scenarios; exposures from food and drinks (including bottled water) and exposure from environmental sources (e.g. air, soil and drinking water).

### *Food and bottled water*

40. The sources of NMPs in food are commonly attributed to those found in the environment, which, likely originated from other sources than the food itself. It is hypothesised that the concentration of NMPs in food and drinks could increase during processing arising from manufacturing equipment, and workers clothing. There is also an increase in the number of studies reporting the presence of MPPs in food crops as a result of agricultural practices such as the use of sludge and plastic mulching. The effect of other processes (e.g. cooking and baking) on the content of plastics is not yet known.

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<sup>6</sup> Further details concerning this research project (FS307021) are available on the [FSA website](#).

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41. As highlighted in earlier sections, the methods for determining microplastics in foods have not been standardised and harmonised. This also includes the methods for sampling and the availability of reference materials.

#### *Analytical detection methodologies*

42. From the literature, the detection methods described for microplastics include one or more of the following steps: sample collection and extraction (or degradation) of biogenic matter, detection and quantification (enumeration) and, the characterisation of the plastic (*i.e.* its chemical composition or polymer type). It is important to note that during all these steps precautions to avoid contamination from particles in the air, or with fibres from clothing, equipment or the reagents used, should be optimised (see *Figure 1.*)

43. As seen in *Figure 1*, the majority of biological samples are taken from aquatic species, the pre-separation includes dissection which recovers MPPs >500 µm, then followed by separation methods including: density separation (floatation, centrifugation and ultrasonic separation), digestion using enzymes and various compounds (*e.g.* hydrogen peroxide, hydrochloric acid, potassium hydroxide *etc*) and filtration techniques. The analytical method is split between three categories: (visual microscopic analysis coupled with or without staining), vibration spectroscopy (*e.g.* FT-IR and Raman spectroscopy) and mass spectroscopy which have been suitable for the characterisation, quantification and identification of nanoplastics (*e.g.* thermodesorption gas chromatography with mass spectrometric detection (TDS-GC-MS) and pyrolysis coupled with gas chromatography and mass spectroscopy (py-GC-MS)).

44. Personal communications with National Reference Laboratories in the UK revealed that organic contaminant analysis only usually analyses the edible portions of food and that contaminants adsorbed to microplastics are generally not taken into account when measuring residues in foodstuff. Although, it was noted that this would be method dependent rather than an intrinsic property.

45. For example, when analysing fish - the head, digestive tract, offal and bones are removed before analysis. It is expected that majority of microplastics are in the GIT; therefore, any contaminants associated with them would not directly contribute to measured contaminant levels. However, depending on the nature of the microplastic (*e.g.* size, type of plastic, age) contaminants may be desorbed in the stomach and may contribute to the measured concentration in the edible parts of the fish (depending on partition between MPP and extraction solvent).

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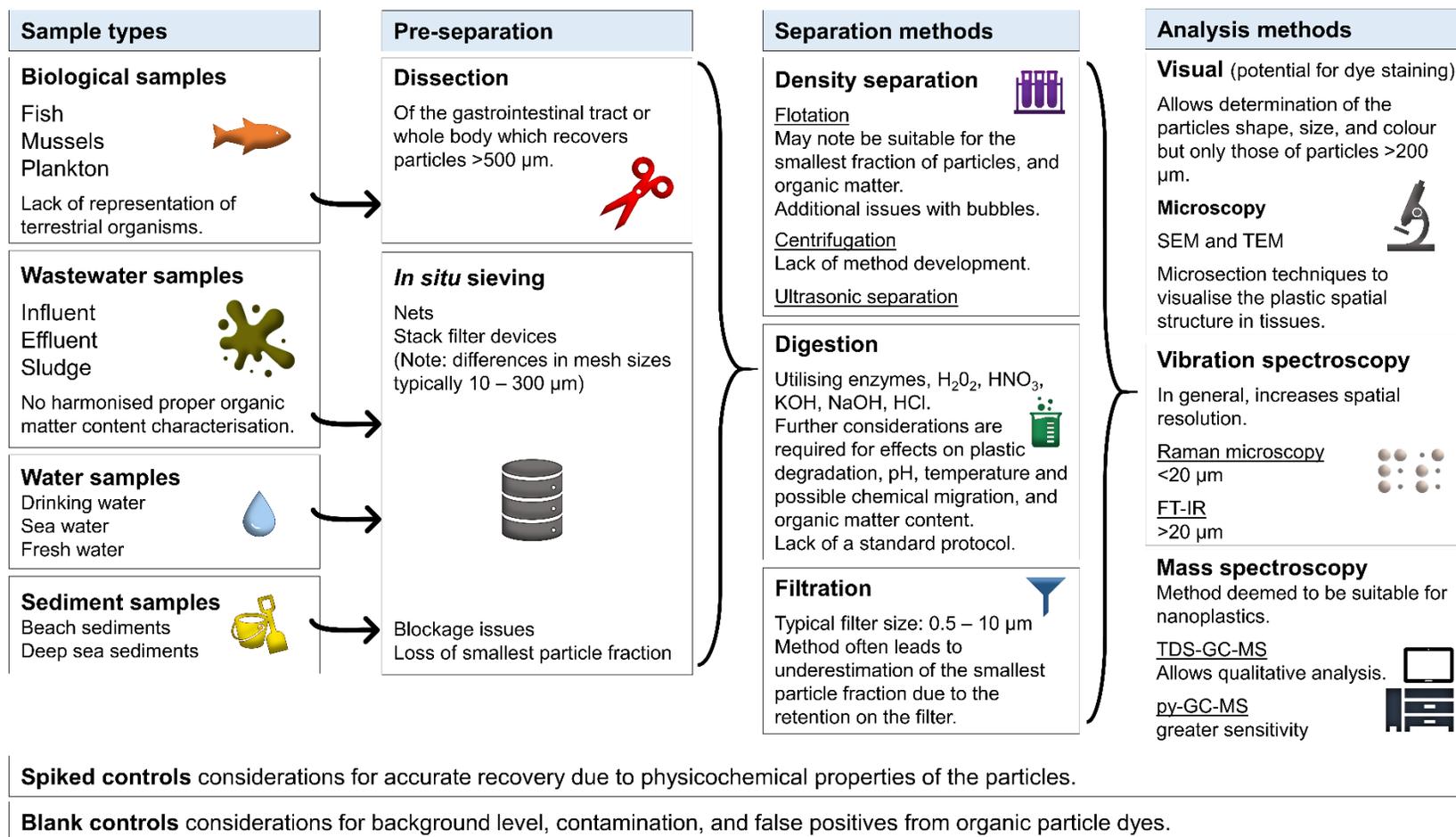


Figure 1 provides an overview of the methodologies utilized in the separation and analysis of microplastics and nanoplastics in complex environmental samples including: biological samples (fish, mussels and plankton), wastewater samples (influent, effluent and sludge), water samples (drinking water, sea water and fresh water) and sediment samples (adapted from Nguyen *et al.*, 2019). Abbreviations: H<sub>2</sub>O<sub>2</sub> = hydrogen peroxide; HNO<sub>3</sub> = nitric acid; KOH = potassium hydroxide; HCl = hydrochloric acid; SEM = Scanning electron microscope; TEM = Transmission electron microscopy; FT-IR = Fourier-transmission infrared; TDS-GC-MS = Thermodesorption gas chromatography- mass spectrometry; py-GC-MS = Pyrolysis gas chromatography-mass spectrometry.

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## *Seafood*

46. Evaluations by the EFSA Contaminants in the Food Chain (CONTAM) Panel focused their efforts on the presence of NMPs in seafood (EFSA, 2016). The occurrence of microplastics has been reported in seafood (between 1 and 7 particles), honey (0.166 fibres/g and 0.009 fragments/g), beer (0.025 fibres/mL, 0.033 fragments/mL and 0.017 granules/mL) and salt (0.007-0.68 particles/g), with most of the data being on occurrence in seafood.

47. It was postulated that MPPs could act as a vehicle for metal (e.g. aluminium, chromium, cobalt, iron, manganese, nickel, zinc, cadmium and lead) transport, however, the EFSA CONTAM Panel could not identify a study that assessed the contribution of metals adsorbed to microplastics in food.

48. The EFSA CONTAM Panel also considered the microbial contamination of microplastics and its relevance to food and consequence(s) to human health, however, due to data limitations it was not possible to perform more detailed risk assessments.

49. In terms of filler materials, the EFSA CONTAM Panel reported that microplastics can contain ~4% of additives and that plastics can adsorb chemicals, and that both can be organic or inorganic. The trophic transfer of contaminants (like persistent organic pollutants) have been reported and biomagnification has been shown. The most commonly reported plastic additives and adsorbed chemicals reported at the time of review include; phthalates, bisphenol A, polybrominated diphenyl ethers, polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs).

50. The EFSA CONTAM Panel made use of the highest concentrations of PAHs and PCBs that had been reported in microplastics deposited at beaches, 24,000 ng/g and 2,750 ng/g, respectively and calculated an estimated exposure of 170 pg of PAHs and 19 pg of PCBs.

51. EFSA had previously estimated the median dietary exposure to PAHs by the European population to be 3.8 µg/day and exposure to PCBs to be 0.3-1.8 µg/day. The increases in these dietary exposures from consuming a portion of mussels per day would be 0.001-0.006% for the PAHs and 0.004% for the PCBs.

52. For fish, only data on microplastics in the digestive tract were available and the digestive tract is usually discarded and not consumed. The EFSA CONTAM Panel considered that the quantity of microplastics in the edible tissue of fish was “likely to be negligible”. A conservative estimate of exposure to microplastics after consumption of a portion of mussels (225 g) was made by EFSA; this was 7 µg of plastics (EFSA, 2016).

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### *Bottled water*

53. In terms of bottled drinking-water; the major polymer type detected is polyethylene terephthalate (PET), which is the most commonly used polymer in bottle manufacturing. Varied quantities and morphology of microplastic particles are reported, depending on material type. The source of microplastic either stems from the packaging itself (e.g. lid cracking) or through manufacturing processes.

### *NMPs in the diet*

54. From the food items described above, humans can be exposed to NMPs in the diet, though the estimation of this is difficult. Presently, the risks from this exposure route to humans are to be fully characterised (Lu *et al.* 2019).

55. From the available toxicokinetic data in animal studies, uptake and distribution of MPs in tissues is partially determined by particle size. Particles >150 µm are not usually taken up, whilst smaller particles especially those within the nanoscale (1-100 nm) have the potential for uptake by organs (as mentioned previously). Microplastics may be taken up into cells but not necessarily into subcellular sites where metabolism takes place thus whilst xenobiotic metabolising enzymes may have the ability to breakdown the chemical, they are not able to access it.

56. While studies in mice have reported that microplastics can perturb gut microbiota processes (Lu *et al.*, 2018; Deng *et al.*, 2017); the Committee concluded that these data could not be easily compared and so it was difficult to draw any meaningful conclusions.

57. Although the presence of microplastics in honey, beer and salt (Liebezeit and Liebezeit, 2013; 2014) have been reported the studies have their limitations. Including the small sample size and most importantly the methodology of identification and quantification of the microplastics involved a simple staining method (fuchsin and Rose Bengal), which was not further characterised with other methods such as FT-IR or Raman spectroscopy.

58. In general, the associated uncertainties with the potential risks from exposure to NMPs in food are: the unavailability of harmonised methodologies to characterise, quantify and identify NMPs; the lack of human toxicokinetic and toxicity data; the paucity of available data for microplastics in different food types and matrices; the difficulty of performing an accurate exposure assessment and therefore a robust risk assessment.

## *Environmental sources*

### Air

59. Environmental exposure to airborne microplastics is dependent on the wide distribution of their sources. Synthetic textiles, erosion of synthetic rubber tyres, and city dust are the most reported sources of airborne microplastics within the literature. Wind transfer is estimated to be responsible for 7% of the ocean's contamination.

60. There is still little information regarding the concentrations of airborne microplastics, however, the Dris *et al.*, (2016, 2017) studies carried out in Greater Paris provides indoor concentrations of 1-60 fibres/m<sup>3</sup> and outdoor concentrations of 0.3-1.5 fibres/m<sup>3</sup>. Data for Central London on deposition rates of microplastics have also been recently reported to range from 575-1,008 fibres/m<sup>2</sup>/day (Wright *et al.*, 2020). Although, these numbers are affected by climate conditions, and seasonality, but also of the sampling methodology.

61. The fate and dispersion of microplastics in indoor and outdoor environments are dependent on several factors that influences human exposure. These factors include; vertical pollution concentration gradient (higher concentrations near the ground), wind speed, land topography, wind speed and direction, precipitation and temperature. Exposure to low concentrations of airborne microplastics is expected in outdoor air due to dilution. The indoor behaviour of airborne microplastics is dependent on factors including room partition, ventilation and airflow, resulting in higher concentrations in rooms downwind.

62. Atmospheric deposition of MPPs onto food prior to consumption must also be considered when assessing exposure.

63. Catarino *et al.*, (2018) compared the potential exposure to humans to household dust fibres during a meal to compare with amounts of microplastics particles present in edible mussels from Scottish waters collected throughout 2015. The mean number of MPPs in *Mytilus modiolus* was 0.086/g ww (n=6). In *Mytilus* spp. the mean number of MPPs/g ww was 3.0 (n=36). Fibres were the most common shape morphology of detected fibres utilising FT-IR and Nile Red staining techniques. PET was estimated to be the most common plastic type. The authors estimated that microplastic ingestion by humans *via* consumption of mussels is 123 MPPs/y/capita in the UK, however, the risk of plastic ingestion *via* mussel consumption was minimal when compared to fibre exposure during an evening meal *via* dust fallout in a household at ~14,000-68,000 MPPs/y/person. This range value was based on the following assumptions; 1 particle per 20 minutes for an area of 4.32 cm<sup>2</sup>, extrapolate this value for a 12.5 cm radius plate, resulting in 114 particles (assuming constant exposure rate), equating to ~42,000 MPPs consumption/year/person, for 20 minutes during consumption of an evening

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meal. During a cooking period of 20 minutes, a constant fibre fallout of 5 MPPs per 4.32 cm<sup>2</sup> was assumed, the potential human ingestion increases to ~207,000 MPPs/year/person. These values were then corrected by 33% which was reported to be the amount of petrochemical based fibres found in dust by Dris *et al.*, (2017).

64. An American study (Cox *et al.*, 2019) has suggested an estimated daily consumption and inhalation of 142 MPPs and 170 MPPs, respectively; this results in a total annual exposure to ~120,00 and ~98,000 MPPs annually in male and female adults, respectively. Although, this calculation did not include values for the atmospheric deposition of microplastics during food preparation and consumption. Should this factor be considered, an estimated additional microplastic fibre exposure of ~14,000-68,000 MPPs/y/person has been calculated during an evening meal *via* dust fallout in a household (based on Catarino *et al.*, 2018).

65. Occupationally inhaled microplastics result in toxicity after inhalation of plastic particles (*i.e.* physical effect) or their leachates (*i.e.* chemical effect). The response in humans depends on differences on individual metabolism and susceptibility. It is not yet known whether synthetic fibres may have similar or lower toxicities when compared to organic/natural fibres.

66. The deposition of inhaled microplastics is dependent on the particle's physicochemical properties, as well as the patient's physiology and lung anatomy. Deposition in the upper airways occurs by impaction, while in the small airways it occurs by sedimentation. Fibres have higher potential for penetration due to its high aspect ratio (Donaldson & Tran, 2002). Clearance relies on mechanical methods (*e.g.* mucociliary clearance where the mucous progresses towards the pharynx caused by the beating of cilia), alveolar macrophage phagocytosis and latter migration and by lymphatic transport.

67. In general, the mechanisms of inhaled particle injury include dust overload (high surface particles induce high chemotactic gradients that prevent macrophage migration), oxidative stress (production of reactive oxygen species, which induces cell injury and release of inflammatory mediators), cytotoxicity (free intracellular particles may damage cellular structures), and translocation (injury of secondary sites and vascular occlusion by particles or increased coagulability). Such mechanisms can lead to toxic endpoints such as cancer, which can develop as a result of chronic inflammation or from gene mutation caused by oxidative stress.

## Soil

68. Plastic mulch films, greenhouse materials and soil conditioners are direct sources of micro and nanoplastics in agriculture. Indirect sources include; general litter, aerial depositing of plastic particles, and the use of treated wastewater and biosolids (*i.e.* sludge). To a lesser extent, composts

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derived from residential or municipal solid waste and garden organic waste are additional sources of plastic pollution in agroecosystems.

69. On the soil surface, plastics degrade *via* the oxidative degradation process which is influenced by various environmental conditions. Plastic particles are reported to form eco-coronas with organic and in-organic soil biota, which may affect its bioavailability and toxicity.

70. Based on the literature, the uptake of MPPs in plants is not expected due to their high molecular weight or their large size. This physicochemical property prevents their penetration through the plant cell wall (Teuten *et al.*, 2009).

71. Information regarding the bioavailability and bioaccumulation of microplastics in soil organisms is generally lacking. Results from studies in earthworms reveal that they either survive and disperse micro- and nanoplastics with them *via* defecation or cast shedding (Huerta Lwanga *et al.*, 2016), or they die as a result of high exposures.

72. Functionalised multi-wall carbon nanotube uptake has been shown in edible food crops (*e.g.* *Arabidopsis* leaves; Zhao *et al.*, 2017). The proposed pathways for entry include; endocytosis *via* the plasmodesmata, passage *via* ion transport channels, carrier proteins or aquaporins, and soil or carbon root exudate mediated entry (Ng *et al.*, 2018).

73. Future research in the analytical and methodological aspects of sampling and quantification are required to perform an accurate assessment of the presence of micro and nanoplastics in soil. Baseline studies on soil exposure, will provide an establishment of the scale of contamination and can potentially allow the determination of sources *e.g.* micro and/or nanoplastics fibres and microbeads as indicators of sludge application for agriculture or tyre dust as an indicator for road runoff. Additional studies are required to assess and better understand microplastic transfer from soil to humans through uptake in food webs and through leaching to the groundwater (Hurley & Nizetto, 2018).

## Water

74. The COT reviewed numerous studies in relation to exposure to NMPs *via* ingestion of water including the World Health Organisation (WHO) report on microplastics in drinking-water (WHO, 2019), key literature articles (Zucarello *et al.*, 2019; Pivonsky *et al.*, 2018) and UK specific data from a Department for Environment, Food and Rural Affairs (Defra) funded study titled, "Sink to River – River to Tap: A review of potential risks from nanoparticles & microplastics." (research code: WT2219)<sup>7</sup>.

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<sup>7</sup> Full report available at the [UKWIR website](#).

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75. In this, the UK water industry has been found to be successful at removing macroplastics >25 µm in size from raw water or crude sewage at >99.99% efficiency. Particles were detected in raw water with an average concentration of 4.9 mpp/L, potable water had an average of 0.00011 mpp/L, whilst the average was 5.1 mpp/L for wastewater effluent samples (determined utilising FT-IR methodologies). Sludge samples were found to have levels of 2,000 – 4,000 mpp/g<sub>dw</sub> due to the high removal rates of MPPs through both water and wastewater treatment processes.

76. Smaller particles (*i.e.* <25 µm) were not analysed and as such the report could not comment on how effective water treatment processes are at filtering these materials. The presence of black particles (such as tyre fragments) were also considered, however, these were difficult to quantify utilising FT-IR, and so were not accounted for within the report.

77. The most common polymer type found in raw water were PE, PET and PP. For potable water, the polymers detected above the limit of quantification were acrylonitrile butadiene styrene and polystyrene, it was hypothesised that these polymers were generated within the water treatment works. Polymers that were detected in wastewater influent and effluent samples were PE, PET and PP (UKWIR, 2019).

78. The WHO Panel concluded that based on the limited evidence available, chemicals and microbial pathogens associated with microplastics in drinking-water pose a low concern for human health, stating that “humans have ingested microplastics and other particles in the environment for decades with no related indication of adverse health effects”. Furthermore, drinking-water treatment is effective at removing particles, especially with advanced membrane filtration techniques which is expected to achieve 100% removal of plastic particles > 0.001 µm for nanofiltration, >0.01 µm for ultrafiltration and >1 µm for microfiltration (WHO, 2019).

79. No epidemiological data or human studies on ingested microplastics were identified by the WHO Panel at the time of review, most toxicological studies have focused on aquatic organisms or ecotoxicology. Data from rat and mice studies were found to be inadequate to inform human health risk assessment of microplastic ingestion.

80. One of the rat studies assessed by the WHO, attempted to establish a no observed adverse effect level (NOAEL) for PET powder (Merski *et al.*, 2008). This was an OECD-compliant 90-day dietary study. PET powder was mixed into the diet of Sprague Dawley rats (n=10/sex) and was dosed at 0, 0.5, 2.5 or 5% PET in the diet. The size and count of the PET particles was not determined/reported; however, it was deemed likely to be in the range of 1-50 µm. No treatment related adverse health effects on blood parameters, organ weights or histopathology, as well as mutagenicity were observed. A no observed adverse effect level was not reported by the authors; however, the

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NOAEL can be considered for the highest dose ~2,500 mg/kg bw/day (at the highest 5% inclusion in the diet).

81. A conservative exposure scenario was carried out by the WHO Panel. Several parameters were assumed prior to the calculation. These were the shape (sphere), size in diameter (150 µm), density (2.3 g/cm<sup>3</sup>) and the number of particles in water (10.4 particles/L). Considering the above assumptions on particle characteristics and a default consumption of drinking water of 2 L/day; an intake of 85 µg of microplastics/day was estimated, which corresponds to 1.4 µg of microplastics/kg bw/day for a 60 kg adult, although, realistic estimates based on reported data ranged from 0.01 – 8.7 µg of microplastics/kg bw/day.

82. No adverse health effects were expected from the following chemical contaminants present in microplastics for drinking-water: bisphenol A, cadmium, chlordane, di(2-ethylhexyl)phthalate, dichlorodiphenyltrichloroethane, hexachlorobenzene, polyaromatic hydrocarbons, polybrominated diphenyl ethers, and polychlorinated biphenyls based on margin of exposure (MOE) calculations.

83. For pathogens in microplastic associated biofilms, the risks were considered to be lower than the risk posed by the high concentrations and diversity of pathogens present in human and livestock waste resulting from inadequate water treatment. Drinking-water treatment processes are designed to remove particles present in the water and the use of disinfection will reduce the potential for any pathogens to be present in drinking-water.

84. With regards to nanoplastics, there was insufficient information available at the time of review for the WHO Panel to be able to draw conclusions on their toxicity, although, no reliable information suggests it is of concern to humans.

85. Much like the scenario with food and bottled water, the associated uncertainties with the potential risks from exposure to NMPs in water include: the unavailability of harmonised methodologies to characterise, quantify and identify NMPs; the lack of toxicokinetic and toxicity data; there is limited data available for microplastics in different food and drink matrices; the difficulty of performing an accurate exposure assessment and subsequent risk assessment.

Other

86. Other sources of NMPs can include the use of cosmetics utilising microbeads, exposure as a result of abrasion for everyday household objects such as cutlery, toothbrush, and cups (Rodrigues *et al*, 2019). It is possible the toddlers may have increased exposure given the number of plastic items can be exposed to during oral exploration as part of a normal stage of development. Moreover, synthetic fibres present in deposited dust, carpets

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*etc* may contribute to human exposure to NMPs particularly by young children due to their frequent hand-to-mouth contacts. However, at the time of review there are no data based on such exposures.

87. The potential exposure of micro and nanoplastics from breast milk to infants were considered, specifically relating to its storage in plastic bottles. The potential risks of ingesting microplastics from bottled water as a source has been discussed. Available data suggest that the presence of MPPs in bottled water are due to the manufacturing process, however, the quality of the plastic and lid cracking have also been found to contribute to the overall number. Thus, it could be hypothesised that mothers storing breast milk for later personal use or for donation to hospitals or milk banks in plastic containers; may be a potential source of micro and nanoplastic exposure to infants.

88. A study by Li *et al.*, (2020) reports microplastics release from the degradation of PP feeding bottles during infant formula preparation. The highest release was recorded at 16,200,000 particles/L, and the release was shown to be dependent on water temperature. The majority of microplastics were <20 µm in size. The potential global exposure to infants up to 12 months old was estimated to range from 14,600- 4,550,000 particles/infant/day. UK infants were estimated to be exposed to >3 million particles/day. Although, the reliability for the methodology protocol was conducted using a recovery test using polystyrene microplastic samples rather than PP.

89. An ongoing study titled Mothers' Information on Lactation and Collection (MILC) study carried out by Bradman and his colleagues at UC Berkeley are assessing breastmilk collection and storage materials to determine whether inappropriate handling and storage increases chemical contamination in breastmilk, however, it is not clear whether the presence of microplastics is within the scope of this research (MILC, 2016). The Secretariat has attempted to contact the researchers for clarification, however, no response had been received by the time of publication.

#### *Tyre and road wear particles (TRWPs)*

90. In terms of TRWPs, tyres contain a wide range of chemicals. The bulk of tyre tread is composed of a variety of rubbers, including natural rubber copolymers, poly-butadiene rubber, styrene-butadiene rubber, nitrile rubber, neoprene rubber, isoprene rubber, and polysulphide rubber. The interaction of tyres and pavement alters both the chemical composition and characteristics of particles generated compared to the original tyre tread due to heat and friction, as well as incorporation of materials such as environmental "dust", brakes, fuels and the atmosphere, as well as roadway particles.

91. Human exposure to chemicals leached from tyres, shredded tyres, and tyre wear material can occur by dermal exposure from environmental sources

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and ingestion of contaminated materials, as well as inhalation of airborne particulate matter derived from tyre wear material.

92. The COT have previously reviewed the initial risk assessments carried out by various assessment groups like the European Tyre and Road Wear Platform; Tyre Industry Project (Jekel, 2019), Joint Research Centre (Grigoratos & Martini, 2014), Defra (AQEG, 2019), Health and Safety Executive (RUBIAC, 2007; HSE, 2011), Committee on Medical Effects of Air Pollution (COMEAP, 2015, 2020), WHO (WHO, 2013), National Institute for Public Health and the Environment (Verschoor *et al.*, 2016), and European Chemicals Agency (ECHA, 2017).

93. The Committee concluded that the literature data on exposure to particles from tyre wear would need separate consideration from microplastic exposure from food, since the particles were chemically quite different in their polymeric nature. The Committee considered that inhalation exposure was likely to be the most significant route. The Committee was of the opinion that uptake by plants and dietary exposure was unlikely to be a major route. Risk assessments of such materials was potentially considered outside of the scope of the current exercise.

### **Summary of exposure sources**

94. The routes for which humans can be exposed to microplastics include the oral and inhalation routes. In terms of the oral route, this is achieved from the consumption of contaminated food products such as seafood (*e.g.* mussels), bottled water, and other food products such as beer, honey, salt, vegetables and tea, which are the foods that have been investigated so far. Potential exposure could also arise from consumption of food crops that have deposited airborne MPPs. Nanoplastic uptake into edible food crops have also been reported within the literature. Other sources of NMPs have also been discussed in paragraphs 86-89.

95. The EFSA CONTAM Panel estimated a total consumption of 7 µg of plastics from a serving of mussels (225 g) (EFSA, 2016). The WHO Panel calculated a conservative estimate of exposure to drinking water at 85 µg MPPs/day, which corresponds to 1.4 µg MPPs/kg bw/day for a 60 kg adult (range 0.01-8.7 µg of MPPs/kg bw/day).

96. Airborne MPPs can also be inhaled. Indoor concentrations of MPPs are thought to be greater than outdoor concentrations due to greater dilution outdoors. Although there is a lack of data on these concentrations; studies from Greater Paris report indoor concentrations of 1-60 fibres/m<sup>3</sup> and outdoor concentrations of 0.3-1.5 fibres/m<sup>3</sup> (Dris *et al.*, 2016, 2017). Data for Central London on deposition rates of microplastics have also been recently reported to range from 575-1,008 fibres/m<sup>2</sup>/day (Wright *et al.*, 2020). These numbers

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are affected by climate conditions, and seasonality, but also by the sampling methodology.

97. As mentioned previously, airborne microplastics can be deposited on food products during various processes (e.g. from manufacturing, equipment and textiles). Estimates of indoor dust fallout during evening meal preparations were estimated to be ~14,000-68,000 MPPs/y/person (Catarino *et al.*, 2018). Estimated daily consumption and inhalation of 142 MPPs and 170 MPPs, respectively was estimated by Cox *et al.*, (2019) for an American individual; resulting in a total annual exposure to ~120,000 and ~98,000 MPPs annually in male and female adults, respectively ( $\pm$  ~14,000-68,000 MPPs/y/person for indoor dust fallout, based on Catarino *et al.*, 2018).

### **Evaluations by other authoritative bodies**

98. The EFSA 2016 statement (EFSA, 2016) and WHO drinking-water report (WHO, 2019) on NMPs have been summarised in paragraphs 46-52, and paragraphs 78-84, respectively.

99. The following section will provide executive summaries on other evaluations carried out by the EU Group of Chief Scientific Advisors; Scientific Advice Mechanism (SAM)<sup>8</sup>, EU Science Advice for Policy by European Academies (SAPEA)<sup>9</sup>, and Environment and Climate Change Canada and Health Canada (ECCC and HC)<sup>10</sup>.

#### *EU Group of Chief Scientific Advisors; Scientific Advice Mechanism (SAM)*

100. In brief, the SAM advisors agreed that most laboratory studies to date does not reflect real-world exposure; and a better understanding is required of the effects of different concentrations, compositions, sizes and shapes of microplastics in ecosystems and humans before robust conclusions can be drawn about real risks.

101. Currently, the available evidence suggests that microplastic pollution at present does not pose widespread risk to humans or the environment, however, there are significant grounds for concern and for precautionary and proportional measures to be taken. These grounds for concern include “the reported adverse effects of acute occupational exposure to microplastics, animal experiments and what is known about the potential hazards”. The measures should aim to: “a. limit the unnecessary use of plastic; b. restrict the intentional use of microplastics; c. prevent or attenuate microplastic formation over the life-cycle of plastics and plastic-containing products; d. avoid release to the environment as near to the source as possible; and e. mitigate and control at key points in pathways from source to sink.”

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<sup>8</sup> The SAM report is available on the [European Commission](#) website.

<sup>9</sup> The SAPEA report is available on the [SAPEA](#) website.

<sup>10</sup> The ECCC and HC report is available on the [Health Canada](#) website.

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102. A clear evidence-based communication of the uncertainties related to the environment, food and human health was also deemed necessary by the SAM advisors.

103. The SAM advisors provided three recommendations. Firstly, the broadening of policy cover to prevent and reduce microplastic pollution. Secondly, to address wider socio-economic and trade-off implications of microplastic pollution and policy actions. Lastly, to promote global cooperation, high-quality scientific exchange and policy coherence (SAM, 2019).

*EU Science Advice for Policy by European Academies (SAPEA)*

104. The SAPEA concluded that there is a need for improved quality and international harmonisation of the methods used to assess exposure, fates and effects of nano- and microplastics on biota and humans (SAPEA, 2019).

105. The conclusion of the working group is that there was no evidence of widespread risk to human health from micro and nanoplastics at present, and that the absence of concrete evidence of microplastic risks at present did not allow us the working group to conclude with sufficient certainty either that risk is present or that it is absent in nature.

106. Adverse effects were observed (negative effect on food consumption, growth, reproduction and survival) once effect thresholds are exceeded. The concentrations utilised are higher than those reported in the environment. Furthermore, the utilisation of virgin or spherical particles are not representative of the environment, and often short exposure times are applied in laboratory studies in the aquatic organisms investigated. As such, there is no evidence that these effects occur in nature. Therefore, these limit the reliability of the risk assessments for micro and nanoplastics.

107. Chemicals associated with microplastics can have additional human health effect(s) (which is deemed difficult to assess), e.g. reproductive toxicity and carcinogenicity, however, the relative contribution to chemical exposure of micro and nanoplastics among the mix of other chemicals probably represents a small proportion.

108. The SAPEA working group recommendations are listed in the following paragraphs. Firstly, it was recommended that there is a need to understand the potential modes of toxicity for different size-shape-type of micro and nanoplastics combinations in selected human models, before robust conclusions real human risks can be made.

109. Secondly, communicating transparently about the uncertainties in the scientific evidence is a safer approach than assuming a lack of risk, especially in sensitive domains such as food and human health. The authors conclude

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that there is consensus and momentum for action and no evidence of “plastic denial” phenomenon. Due to the lack of scientific understating, the precautionary principle has been part of the foundation for current regulations.

110. Close interdisciplinary collaboration between the natural, social and behavioural, and regulatory sciences was recommended as a way forward for addressing the complex issue of plastic waste and pollution.

111. The working group further concluded that it would be important to implement both agreements and legislation which focus on emission reduction and the use of less hazardous materials. Evidence suggests that focus should be on circular economy approaches, away from linear processes and end-of life clean-up.

*Environment and Climate Change Canada and Health Canada (ECCC and HC)*

112. ECCC and HC published a report on their science assessment of plastic pollution (ECCC & HC, 2020). The intended purpose of the report is to act as a guide for future scientific and regulatory activities; not to quantify the risks of plastic pollution on the environment or human health.

113. The ECCC and HC summarised that humans may be exposed to microplastics *via* the ingestion of food, bottled water, and tap water, as well as through the inhalation of indoor and outdoor air. However, information on the human health effects of microplastics is limited, and further research is required to better inform target tissues, threshold doses, and mode of action.

114. Although there were some associations between exposures to high levels of microplastics and adverse health effects in laboratory animals and in humans (occupational data) have been reported; the ECCC and HC deemed that “these health effects cannot be linked to exposure in the general population” and noted that conflicting observations have been made for cancers of the respiratory tract and digestive system.

115. The reviewed scientific literature did not identify a concern for human health, however, the ECCC and HC stressed that there are insufficient data to allow for a robust evaluation of the potential human health risks of ingested microplastics. As for the available inhalation studies, no dose-response relationship has been observed in mortality, survival time, behaviour, clinical observations, or tumour incidence from inhalation exposures.

116. In terms of the risks from sorbed and chemically bound (e.g. persistent organic pollutants) and unbound chemicals (e.g. monomers) on plastic particles, current available literature indicate that there is likely a low health concern for human exposure to chemicals from ingestion of microplastics from food or drinking water.

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117. As for the presence and formation of biofilms on the surface of MPPs, the ECCC and HC indicated that there is currently no indication that this would impact human health. Despite limited data, it is anticipated that drinking water treatment processes have the ability to inactivate biofilm-associated microorganisms.

118. To conclude, the ECC and HC are in the view that under the precautionary principle, further action is needed to reduce the presence of macro- and microplastics that end up in the environment.

119. The following research needs were recommended in order to carry out a human health risk assessment; development of standardised methods for sampling, quantifying, characterising, and evaluating the effects of macro and microplastics, studies to further understand the extent of human exposure to microplastics and its effect(s) to human, and lastly, to expand and develop consistent monitoring efforts to include poorly characterised environmental compartments such as soil.

### **COT evaluation**

120. Microplastics are widespread, they are either intentionally added to products or occur as a result of plastics being fragmented down into smaller sizes by natural processes such as wear, weathering and corrosion. There is no internationally agreed definition of what a microplastic is, however, there is a general acceptance that the size range is from 0.1-5,000  $\mu\text{m}$ .

121. MPPs  $>150 \mu\text{m}$  are unlikely to be absorbed. Particles  $<50 \mu\text{m}$  could be adsorbed from the gut *via* tight junction gaps and endocytic pathways but only those of  $<1\text{-}2 \mu\text{m}$  in size were able to cross cell membrane organs.

122. The uptake of these smaller microplastics (*i.e.*  $<50 \mu\text{m}$ ) was expected to be limited ( $\leq 0.3\%$ ). The absorption and distribution may be more significant for nanoplastics (up to 7% for  $<0.1 \mu\text{m}$  particles) than microplastics (WHO, 2019).

123. The risk of chemical leachates and adsorbed substances from microplastics is not expected to cause adverse health effects in humans due to their small contribution to the overall exposure from other sources of the same chemical as evidenced by the EFSA 2016 review and the WHO 2019 MOE calculations.

124. Other evaluations by the SAM, SAPEA, ECCC and HC further support the above conclusion.

125. Presently, a full risk assessment on the potential toxic effect(s) of micro and/or nanoplastics could not be carried out due to several data gaps including: the unavailability of harmonised methodologies to characterise, quantify and identify NMPs; the lack of human toxicokinetic and toxicity data;

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the paucity of currently available data for microplastics in different food types and matrices being limited; the difficulty of performing an accurate exposure assessment. Furthermore, there is no established NOAEL for the different polymer types except for PET powder at 2,500 mg/kg bw/day in rats, (see paragraph 80), which had a number of limitations (size and count were not determined/reported); this material type may also not be representative of NMPs found in the environment.

126. The lack of reliable data has been noted. Koelmans *et al.*, (2019) proposed a quality assessment criterion to rank the reliability of published results in literature with the aim to better understand the potential exposure and to inform human health risk assessments. There are nine criteria based on reproducibility, precision, accuracy and sensitivity; these are sampling method, sample size, sample processing and storage, laboratory preparation, clean air conditions, negative controls, positive controls, core sample treatment and polymer identification. For each criterion, a value of 2 (reliable), 1 (reliable to a limited extent) or 0 (unreliable) is assigned. Therefore, the "Total Accumulated Score" is calculated by adding scores for individual criteria (maximum 18 points). For data to be considered reliable, a study should preferably have no 'zero' values for any of the individual scores.

127. As highlighted throughout the document, microplastics have many varying physicochemical properties to suit its primary purpose, however, these properties do not correlate to secondary microplastics where they are fragmented down as a result of natural processes (and as such are not considered pristine). Additionally, analytical methodology processes are limited to FT-IR, Nile Red, qNMR, Micro-Raman spectroscopy and mass-spectroscopy. There are no standardised testing methods for different matrices (*i.e.* air, soil, food and water), and the available methods have their own associated limitations (see *Figure 1*). Furthermore, no single technique is suitable for all plastic types and for all particle sizes or shapes. Using a suite or generation of new techniques may be necessary.

128. In terms of the toxicity of NMPs, there is no established NOAEL for each polymer type (except PET powder at 2,500 mg/kg bw/day in rats as reported by Merski *et al.*, 2008). Available data on the ECHA REACH database relates to the starting materials *i.e.* the monomers. Furthermore, variability in exposure routes must also be considered.

129. For the reasons above, a case-by-case approach to risk assessments may need to be considered.

130. Other challenges include the difficulties in the comparison of published studies due to differences in sampling, extraction, purification and analytical methods for enumerating and characterising microplastics are not yet standardised, and therefore suitable reference materials are also required. The Committee note that different types of plastic particles are being utilised based on endpoint specific or target organ analysis, which further adds to the

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challenges of comparing available data. Contamination with airborne microplastics or cross-contamination of samples pose as an issue, control samples may be difficult to ascertain.

131. Most studies have performed tests on pristine particles; therefore, it is important to consider inter-variability of samples and batches and how this may not be representative of what is present in the environment (*i.e.* particles have not undergone degradative processes in the environment).

### **Research priorities for risk assessment**

132. Current research efforts from the UK FSA include a critical review of microbiological colonisation of nano-and microplastics (as described in paragraph 38). The National Institute for Health Research Health Protection Unit in Environmental Exposures and Health at Imperial College London are also carrying out research to determine if microplastics have detrimental human health effects<sup>11</sup>.

133. The COT recommends the following research priorities for the risk assessment of NMPs.

134. Comprehensive assessment of MPs and contaminant concentrations in seafood species and the impact of what cooking may have on the desorption and subsequent bioavailability of contaminants/leachants, needs to be further investigated to better understand the implications for human health.

135. Considerations for the potential degradation of novel/emerging plastic-based materials on the market such as biobased plastics (*e.g.* bamboo ware, polylactic acid, chitin *etc.*) into NPMs during its use and end-of-life should be taken into account when considering the bigger picture of potential risks of exposure, as it is unclear how much they already contribute to the microplastics issue.

136. Current studies typically only deal with one type of particle/tissue interaction, as such, further research is necessary to explore the effects of the combination of particle types *in vitro* (*e.g.* *in silico* assessments, organ on a chip, organoids *etc.*) and/or *in vivo*.

137. Since microplastic concentrations are expected to increase in the future, it will be important to establish a monitoring program to regularly assess the levels of microplastics in food, water and the air. This would need collaborations between academia, researchers and government bodies at a national and international level.

138. There is also a need to study the assimilation of a range of microplastic sizes and compositions into human tissues and in the development of

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<sup>11</sup> Further information on other research themes is available on the [EEH HPRU website](#).

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techniques capable of identifying the presence of microplastics in the human body (e.g. biopsies and tissue banks).

139. The most significant data gaps that hinders a robust risk assessment for the potential risks of exposure *via* the oral route include the lack of: appropriate and harmonised analytical methods for the detection of different micro and nanoplastics in various food matrices; understanding of human exposure and; there is also a lack of data with regards to the absorption, metabolism, distribution and excretion (*i.e.* the toxicokinetic profile) and toxic profiles on NMPs in human.

140. For the inhalation route the significant data gaps include the lack of: harmonised analytical methods for detection of different micro and nanoplastics during sample collection; understanding the effects of differing exposure scenarios (e.g. indoor and outdoor environments); understanding how different lung disease states may also implicate the observed effects from microplastic exposure; and from available occupation data – how this may be extrapolated to a general population.

### **COT Conclusions**

141. The COT noted that there are limited data regarding the toxicokinetic fate of orally ingested microplastics in mammalian species, and that they can either remain confined in the GIT, translocate from the GIT into organs or tissues (via endocytosis in M cells and paracellular persorption), and/or be excreted (~>90%). No epidemiological or controlled dose studies that evaluated the effects of orally ingested microplastics in humans were identified.

142. As such, the COT concludes that based on the available data, it is not yet possible to perform a complete risk assessment for the potential risks from exposure to micro and nanoplastics *via* the oral and inhalation routes, however, they concur with the conclusions reached by other authoritative bodies (EFSA, WHO, ECCC and HC, SAPEA, SAM, as described in their relevant sections in this document).

143. The Committee concluded that the literature data on exposure to particles from tyre wear would need separate consideration from microplastic exposure from food, since the particles were chemically quite different in their polymeric nature. Risk assessment of such material was considered potentially outside the scope of the current exercise.

144. The most significant data gaps appear to be the lack of appropriate and harmonised analytical methods for the detection of micro- and nanoplastics (together with suitable reference standards), as well as their toxicokinetic and toxicity profiles in/relevant for humans.

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145. The Committee highlighted that additional information will be needed from all exposure sources, which include indoor and outdoor air, dust and soil. The presence of MPs in seafood and water may need to be put into perspective with other sources of MPs such as atmospheric fallout.

146. Comprehensive assessment of microplastics and contaminant concentrations in seafood species and the impact of what cooking may have on the desorption and subsequent bioavailability of contaminants/leachants, needs to be further investigated to better understand the implications for human health.

147. Current studies typically only deal with one type of particle/tissue interaction, as such, further research is necessary to explore the effects of the range of particle types *in vitro* and/or *in vivo*. These range of particle types must also take into account emerging/novel plastic-based materials such as bioplastics.

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## Abbreviations

COT	Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment
COMEAP	Committee on Medical Effects of Air Pollution
CONTAM	Contaminants in the Food Chain
Defra	Department for Environment, Food and Rural Affairs
ECC	Environment and Climate Change
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
FT-IR	Fourier-transform infrared spectroscopy
GIT	Gastrointestinal tract
HC	Health Canada
MILC	Mothers' information on lactation and collection
MOE	Margin of exposure
MPPs	Microplastic particles
NEE	Non-exhaust emission
NMPs	Nano- and microplastics
NOAEL	No observed adverse effect level
OECD	Organisation for Economic Co-operation and Development
PAHs	Polyaromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PE	Polyethylene
PET	Polyethylene terephthalate
PM <sub>10</sub>	Particulate matter (10 µm)
PP	Polypropylene
py-GC-MS	Pyrolysis coupled with gas chromatography and mass spectroscopy
RUBIAC	Rubber Industry Advisory Committee
SAM	EU Group of Chief Scientific Advisors; Scientific Advice Mechanism
SAPEA	EU Science Advice for Policy by European Academies
TDS-GC-MS	Thermodesorption gas chromatography with mass spectrometric detection
TWPs	Tyre wear particles
TWRPs	Tyre and road wear particles
UK	United Kingdom
UKWIR	United Kingdom Water Industry Research
US	United States
VOCs	Volatile organic compounds
WHO	World Health Organisation

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## References

- AQEG. (2019) Non-exhaust emissions from road traffic. Available at: [https://ukair.defra.gov.uk/assets/documents/reports/cat09/1907101151\\_20190709\\_Non\\_Exhaust\\_Emissions\\_typeset\\_Final.pdf](https://ukair.defra.gov.uk/assets/documents/reports/cat09/1907101151_20190709_Non_Exhaust_Emissions_typeset_Final.pdf). Accessed: 17/17/2020.
- Baensch-Baltruschat, B., Kocher, B., Stock, F., Reifferschied, G. (2020) Tyre and road wear particles (TRWP) – A review of generation, properties, emissions, human health risks, ecotoxicity, and fate in the environment. *Science of the Total Environment* 733, 137823.
- Barrero-Moreno, J., Senaldi, C., Bianchi, I., Geiss, O., Tirendi, S., Folgado de Lucena, A., Barahona, F., Mainardi, G., Leva, P. and Aguar-Fernandez, P. (2018) Migration of Polycyclic Aromatic Hydrocarbons (PAHs) from plastic and rubber articles - Final report on the development of a migration measurement method. JRC Technical Reports JRC111476. Available at: <https://publications.jrc.ec.europa.eu/repository/bitstream/JRC111476/kjna29282enn.pdf>. Accessed: 17/08/2020.
- California Water Boards. (2020) State Water Resources Control Board Resolution No. 2020-0021. Adoption of definition of 'Microplastics in Drinking Water'. Available at: [https://www.waterboards.ca.gov/board\\_decisions/adopted\\_orders/resolutions/2020/rs2020\\_0021.pdf](https://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/2020/rs2020_0021.pdf). Accessed: 01/09/2020.
- COMEAP. (2015) Statement on the evident for differential health effects of particulate matter according to source or components. Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/411762/COMEAP\\_The\\_evidence\\_for\\_differential\\_health\\_effects\\_of\\_particulate\\_matter\\_according\\_to\\_source\\_or\\_component\\_s.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/411762/COMEAP_The_evidence_for_differential_health_effects_of_particulate_matter_according_to_source_or_component_s.pdf). Accessed: 03/01/2020.
- COMEAP. (2020) Statement on the evidence for health effects associated with exposure to non-exhaust particulate matter from road transport. Available at: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/917308/COMEAP\\_Statement\\_on\\_the\\_evidence\\_for\\_health\\_effects\\_associated\\_with\\_exposure\\_to\\_non\\_exhaust\\_particulate\\_matter\\_from\\_road\\_transport\\_-COMEAP-Statement-non-exhaust-PM-health-effects.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/917308/COMEAP_Statement_on_the_evidence_for_health_effects_associated_with_exposure_to_non_exhaust_particulate_matter_from_road_transport_-COMEAP-Statement-non-exhaust-PM-health-effects.pdf). Accessed: 19/11/2020.
- Cox, K. D., Covernton, G. A., Davies, H. L., Dower, J. F., Juanes, F., Dudas, S. E. (2019) Human consumption of microplastics. *Environmental Science & Technology* 53, pp. 7068-7074.
- Culp, S. J., Gaylor, D. W., Sheldon, W. G., Golstein, L. S. and Beland, F. A. (1998) A comparison of the tumors induced by coal tar and benzo[a]pyrene in a 2-year bioassay. *Carcinogenesis* 19, pp 117–124.
- Deng, Y., Zhang, Y., Lemos, B. and Ren, H. (2017) Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure. *Scientific Reports* 7, 46687.
- Donaldson, K., and Lang Tran, C. (2002) Inflammation caused by particles and fibres. *Inhalation Toxicology* 14, pp. 5-27.
- Dris, R., Gasperi, J., Saad, M., Mirande, C. and Tassin, B. (2016) Synthetic fibres in atmospheric fallout: A source of microplastics in the environment? *Marine Pollution Bulletin* 104, pp. 290-293.

This is a draft statement for discussion.  
It does not reflect the final views of the Committee and should not be cited.

- Dris, R., Gasperi, J., Mirande, C., Mandin, C., Guerrouache, M., Langlois, V. and Tassin, B. (2017) A first overview of textile fibres, including microplastics, in indoor and outdoor environments. *Environmental Pollution* 221, pp. 453-458.
- ECHA. (2017) Annex XV Report. An evaluation of the possible health risks of recycled rubber granules used as infill in synthetic turf sports fields. Available at: [https://echa.europa.eu/documents/10162/13563/annexxv\\_report\\_rubber\\_granules\\_en.pdf/dbcb4ee6-1c65-af35-7a18-f6ac1ac29fe4](https://echa.europa.eu/documents/10162/13563/annexxv_report_rubber_granules_en.pdf/dbcb4ee6-1c65-af35-7a18-f6ac1ac29fe4). Accessed: 14/01/2020.
- ECHA. (2019) Annex XV Restriction Report Proposal for a Restriction for intentionally added microplastics. Available at: <https://echa.europa.eu/documents/10162/05bd96e3-b969-0a7c-c6d0-441182893720>. Accessed: 10/11/2020/
- EFSA. (2009) The potential risks arising from nanoscience and nanotechnologies on food and feed safety. *The EFSA Journal* 958, pp. 1-39. Available at: <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.958>. Accessed: 01/09/2020.
- EFSA. (2016) Presence of microplastics and nanoplastics in food, with particular focus on seafood. *The EFSA Journal* 14, 4501. Available at: <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2016.4501>. Accessed: 04/08/2020.
- EFSA. (2018) Guidance on risk assessment of the application of nanoscience and nanotechnologies in the food and feed chain: Part 1, human and animal health. *The EFSA Journal* 16, 5327. Available at: <http://www.efsa.europa.eu/en/efsajournal/pub/5327>. Accessed: 01/09/2020.
- EFSA. (2020) EFSA Guidance on technical requirements for regulated food and feed product applications to establish the presence of small particles including nanoparticles. Available at: <https://www.efsa.europa.eu/sites/default/files/consultation/consultation/Draft-Nano-Technical-Guidance-For-Public-Consultation.pdf>. Accessed: 10/11/2020.
- FSA. (2020) A critical review of microbiological colonisation of nano-and microplastics (NMPs) and their significance to the food chain. Available at: <https://www.food.gov.uk/research/research-projects/a-critical-review-of-microbiological-colonisation-of-nano-and-microplastics-nmps-and-their-significance-to-the-food-chain>. Accessed: 24/08/2020.
- Gasperi, J., Wright, S., L., Dris, R., Collard, F., Mandin, C., Guerrouache, M., Langlois, V., Kelly, F. J. and Tassin, B. (2018) Microplastics in air: Are we breathing it in? *Current Opinion in Environmental Science & Health* 1, pp. 1-5.
- Grigoratos, T., Martini, G. (2014) Non-exhaust traffic related emissions. Brake and tyre wear PM; Literature review. Available at: <https://publications.jrc.ec.europa.eu/repository/bitstream/JRC89231/jrc89231-online%20final%20version%202.pdf>. Accessed: 17/08/2020.
- Hartmann, N. B., Hüffer, T., Thompson, R. C., Hassellöv, M., Verschoor, A., Daugaard, A. E., Rist, S., Karlsson, T., Brennholt, N., Cole, M., Herrling, M. P., Hess, M. C., Ivleva, N. P., Lusher, A. L. and Wagner, M. (2019) Are we speaking the same language? Recommendations for a definition and

This is a draft statement for discussion.  
It does not reflect the final views of the Committee and should not be cited.

- categorization framework for plastic debris. *Environmental Science and Technology* 53, pp. 1039-1047.
- Hillerdal, G., Steinholtz, Rosenhall, L. and Lindgren, A. (1988) Pulmonary fibrosis caused by synthetic textile fibres? VIIth International Pneumoconioses Conference, pp. 1405-1407. Available at: <https://www.cdc.gov/niosh/docs/90-108/pdfs/90-108-2.pdf?id=10.26616/NIOSH PUB90108>. Accessed: 15/08/2019.
- HSE. (2011) Safe to Breathe: Dust and fume control in the rubber industry. Available at: <https://www.hse.gov.uk/pubns/iacl95.htm>. Accessed: 02/01/2019.
- Huerta Lwanga, E., Gertsen, H., Gooren, H., Peters, P., Salánki, T., van der Ploeg, M., Besselingm E., Koelmans, A. A. and Geissen, V. (2016) Microplastics in the terrestrial ecosystem: Implications for *Lumbricus terrestris* (Oligochaeta, Lumbricidae). *Environmental Science & Technology* 50, pp. 2685-2691.
- Hurley, R. R., Nizzetto, L. (2018) Fate and occurrence of micro(nano) plastics in soils: Knowledge gaps and possible risks. *Current Opinion in Environmental Science and Health* 1, pp. 6-11.
- Jekel, M. (2019) Scientific report on tyre and road wear particles, TRWP, in the aquatic environment a European TRWP Platform publication. Available at: <https://www.tyreandroadwear.com/wp-content/uploads/2019/10/FINAL-ScientificReport-on-Tyre-and-Road-Wear-Particles.pdf>. Accessed: 19/12/2019.
- Koelmans, A. A., Nor, N. H. M., Hermsen, E., Kooi, M., Mintenig, S. M., De France, J. (2019) Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. *Water Research* 155, pp. 410-422.
- Kole, P. J., Löhr, A. J., Van Belleghem, F. G. A. J. and Ragas, A. M. J. (2017) Wear and Tear of Tyres: A stealthy source of microplastics in the environment. *International Journal of Environmental Research and Public Health* 14, 1265.
- Li, D., Shi, Y., Yang, L., Xiao, Kehoe, D. K., Gun'ko, Y. K., Boland, J. J. and Wang, J. J. (2020) Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation. *Nature Food* 1, pp. 746-754.
- Liebezeit, G. and Liebezeit, E. (2013) Non-pollen particulates in honey and sugar. *Food Additives and Contaminants. Part A, Chemistry, Analysis, Control, Exposure and Risk Assessment* 30, pp. 2136–2140.
- Liebezeit, G. and Liebezeit, E. (2014) Synthetic particles as contaminants in German beers. *Food Additives and Contaminants. Part A, Chemistry, Analysis, Control, Exposure and Risk Assessment* 31, pp. 1574–1578.
- Lu, L., Wan, Z., Luo, T., Fu, Z. and Jin, Y. (2018) Polystyrene microplastics induce gut microbiota dysbiosis and hepatic lipid metabolism disorder in mice. *Science of the Total Environment* 631-632, pp. 449-458.
- Lu, L., Lou, T., Zhao, Y., Cai, C., Fu, Z. and Jin, Y. (2019) Interaction between microplastics and microorganism as well as gut microbiota: A consideration on environmental animal and human health. *Science of the Total Environment* 667, pp. 94-100.
- Merola, M. and Affatato, S. (2019) Materials for hip prostheses: A review of wear and loading considerations. *Materials* 12, 495.
- Merski, J. A., Johnson, W. D., Muzzio, M., Lyang, N. L. and Gaworski, C. L. (2008) Oral toxicity and bacterial mutagenicity studies with a spun bound

This is a draft statement for discussion.  
It does not reflect the final views of the Committee and should not be cited.

- polyethylene and polyethylene terephthalate polymer fabric. *International Journal of Toxicology* 27, pp. 387-395.
- MILC. (2016) Mothers' information on lactation and collection (MILC) study. Available at: <http://www.milcstudy.com/>. Accessed: 14/08/2020.
- Ng, E-L., Huerta Lwanga, E., Eldridge, S. M., Johnston, P., Hu, H-W., Geissen, V., Chen, D. (2018) An overview of microplastic and nanoplastic pollution in agroecosystems. *Science of the Total Environment* 627, pp. 1377- 1388.
- Nguyen, B., Claveau-Mallet, D., Hernandez, L. M., Xu, E. G., Farner, J. M. and Tufenkji, N. (2019) Separation and analysis of microplastics and nanoplastics in complex environmental samples. *Accounts of Chemical Research* 52, pp. 858-866.
- Pauly, J. L., Stegmeier, S. J., Allaart, H. A., Cheney, R. T., Zhang, P. J., Mayer, A. G. and Streck, R. J. (1998) Inhaled cellulosic and plastic fibres found in human lung tissue. *Cancer Epidemiology, Biomarkers and Prevention* 7, pp. 419-428.
- Peez, N., Janiska, M-C. and Imhof, W. (2019) The first application of quantitative <sup>1</sup>H NMR spectroscopy as a simple and fast method of identification and quantification of microplastic particles (PE, PET, and PS). *Analytical and Bioanalytical Chemistry* 411, pp. 823-833.
- Pimentel, J. C., Avila, R. and Lourenço, A. G. (1975) Respiratory disease caused by synthetic fibres: a new occupational disease. *Thorax* 30, pp. 204-219.
- Pivovsky, M., Cermakova, L., Novotna, K., Peer, P., Cajthaml, T. and Janda, V. (2018) Occurrence of microplastics in raw and treated drinking-water. *Science of the Total Environment* 643, pp. 1644-1651.
- RUBIAC. (2007) RUBIAC statement on occupational cancers. Available at: <https://www.hse.gov.uk/rubber/cancerstatement.htm>. Accessed: 17/07/2020.
- SAM. (2019) Environmental and Health Risks of Microplastic Pollution. Available at: [https://ec.europa.eu/info/sites/info/files/research\\_and\\_innovation/groups/sam/ec\\_rtd\\_sam-mnp-opinion\\_042019.pdf](https://ec.europa.eu/info/sites/info/files/research_and_innovation/groups/sam/ec_rtd_sam-mnp-opinion_042019.pdf). Accessed: 17/08/2020.
- Teuten, E. L., Saquing, J. M., Knappe, D. R. U., Barlaz, M. A., Jonsson, S., Björn, A., Rowland, S. J., Thompson, R. C., Galloway, T. S., Yamashita, R., Ochi, D., Watanuki, Y., Moore, C., Viet, P. H., Tana, T. S., Prudente, M. P., Boonyatumanond, R., Zakaria, M. P., Akkhang, K., Ogata, Y., Hirai, H., Iwasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Saha, M. and Takada, H. (2009) Transport and release of chemicals from plastics to the environment and to wildlife. *Philosophical Transactions of the Royal Society B* 364. Article ID: 20080284.
- Toussaint, B., Raffael, B., Angers-Loustau, A., Gilliland, D., Kestens, V., Petrillo, M., Rio-Echevarria, I.M. and Van den Eede, G. (2019) Review of micro- and nanoplastic contamination in the food chain. *Food Additives & Contaminants: Part A*, 36(5), pp. 639-673.
- UKWIR. (2019) Sink to river – River to tap: A review of potential risks from nanoparticles and microplastics. Available at: [https://ukwir.org/view/\\$NvDnwfm](https://ukwir.org/view/$NvDnwfm). Accessed: 10/09/2019.
- Verschoor, A. J. (2015) Towards a definition of microplastics. Available at: <https://www.rivm.nl/bibliotheek/rapporten/2015-0116.pdf>. Accessed: 04/08/2020.
- Verschoor, A., de Valk, E. (2016) Emission of microplastics and potential mitigation measures: Abrasive cleaning agents, paints and tyre wear RIVM

This is a draft statement for discussion.  
It does not reflect the final views of the Committee and should not be cited.

- Report 2016-0026. Available at:  
<https://www.rivm.nl/bibliotheek/rapporten/2016-0026.pdf>. Accessed:  
17/08/2020.
- Villarrubia-Gómez, P., Cornell, S.E. and Fabres, J. (2018). Marine plastic pollution as a planetary boundary threat–The drifting piece in the sustainability puzzle. *Marine Policy*, 96, pp. 213-220.
- Wagner, S., Hüffer, T. Klöckner, P., Wehrhahn, M., Hofmann, T. and Reemtsma, T. (2018) Tire wear particles in the aquatic environment - A review on generation, analysis, occurrence, fate and effects. *Water Research*, 139, pp. 83-100.
- WHO. (2013) Review of evidence on health aspects of air pollution – REVIHAAP Project Technical Report. Available at:  
[http://www.euro.who.int/\\_data/assets/pdf\\_file/0004/193108/REVIHAAP-Finaltechnical-report.pdf](http://www.euro.who.int/_data/assets/pdf_file/0004/193108/REVIHAAP-Finaltechnical-report.pdf). Accessed: 03/01/2020.
- WHO. (2019) Microplastics in drinking-water. Available at:  
[https://www.who.int/water\\_sanitation\\_health/publications/microplastics-in-drinking-water/en/](https://www.who.int/water_sanitation_health/publications/microplastics-in-drinking-water/en/). Accessed: 17/08/2020.
- Wright, S., L., Ulke, J., Font, A., Chan, K. L. A. and Kelly, F. J. (2020) Atmospheric microplastic deposition in an urban environment and an evaluation of transport. *Environment International* 136, 105411.
- Zhao, Q., Ma, C., White, J. C., Dhankher, O. P., Zhang, X., Zhang, S. and Xing, B. (2017) Quantitative evaluation of multi-wall carbon nanotube uptake by terrestrial plants. *Carbon* 114, pp. 661-670.
- Zucarello, P., Ferrante, M., Cristaldi, A., Copat, C., Grasso, A., Sangregorio, D., Fiore, M., and Oliveri Conti, G. (2019) Exposure to microplastics (<10 µm) associated to plastic bottles mineral water consumption: The first quantitative study. *Water Research* 157, pp. 365-371.