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Where is the evidence that human exposure to microplastics is safe?

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Both the European Commission's Science Advice for Policy organ, SAPEA, and the World Health Organization (WHO) launched reports (SAPEA, 2019; World Health Organization, 2019) stating that very little published data is available regarding either exposure to, or the toxicity of microplastics and nanoplastics in humans. The reports acknowledge the current challenges facing scientists attempting to gather robust information and recommend proceeding to fill knowledge gaps. The SAPEA report states on p. 116 that '*the absence of evidence of microplastics risks currently does not allow one to conclude that risk is either present or absent with sufficient certainty*' (SAPEA, 2019). In this absence of evidence, it is then surprising to find statements on SAPEA's homepage that the final *'verdict'* of SAPEA's Evidence Review Report is that '*The best available evidence suggests that microplastics and nanoplastics do not pose widespread risk to humans and the environment'*. Similarly, the WHO (World Health Organization, 2019) concludes that *'humans have ingested microplastics and other particles in the environment for decades with no related indication of adverse health effects'* and that there is *'no evidence to indicate a human health concern'*. Many mainstream media have picked up the 'no risk' soundbite. These statements raise a fundamental epistemological problem.

Can the conclusion of 'no risk' be supported by 'no data'? One of the common pitfalls in critical thinking is to neglect the logic that the absence of evidence is not evidence of absence. The *'having plastic particles in your body is safe'* conclusion conjures up a classic error known as the '*appeal to ignorance'* fallacy Locke (1690), which is, *'there is no evidence against x. Therefore x is true.'* This type of statement has no place in rational thinking. Note that to propagate claims of this type is to unduly shift the burden of proof onto those seeking conclusive evidence.

The SAPEA report on p. 88 duly warns us against the hazards of miscommunicating the absence of evidence: '*Communicating transparently about the uncertainties in scientific evidence is a safer approach than assuming and communicating a lack of risk, especially in sensitive domains such as food and human health*' (SAPEA, 2019). It is important to realize that a statement of absence of evidence of risk can be all too easily perceived as a statement of no risk.

Should researchers in the plastic particle trenches let these slip ups go, and just focus time and attention on the arduous task of generating the missing data needed to understand the risks empirically? Certainly not. As Bertrand Russell remarked, '*Logical errors are, I think, of greater practical importance than many people believe; they enable their perpetrators to hold the comfortable opinion on every subject in turn.*' (Russell, 1946). We agree.

As soon as science and public opinion about environment and health issues settle into comfortable standpoints based on logical errors, we risk getting into trouble. Complacency needs to be challenged. Good science always welcomes debate and rigorous discourse that includes a multiplicity of voices hashing things out. Avoiding such engagement impedes progress down the path of knowing what is really going on.

Scientific conclusions are regarded by philosophers of science as subjective statements unavoidably reflecting the beliefs of the authors. Nonetheless, researchers make every effort to let go of their preconceptions as a vital part of the scientific process. Conclusions from authoritative, powerful institutions can strongly impact how future research is framed, how funding is allocated, and how policy inaction or

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action is justified. A message now in circulation is that there's nothing to worry about when it comes to micro- and nanoplastics and human health. We saw above that the statements regarding health risks are not logical. More importantly, they may not be true.

The European Environment Agency's two *Late Lessons from Early Warnings* reports (European Environment Agency, 2013; European Environment Agency, 2001) highlighted the danger. The reports analyze the impact of past inaction (or action) on environmental damage caused by, for example, polychlorinated biphenyls (PCBs), and public health issues generated by exposure to asbestos or diethylstilbestrol (DES). Each case is deconstructed to identify patterns leading to delays in appropriate decision making. The insights led to recommendations regarding how to respond to new warnings with the precautionary principle, i.e. to act to reduce potential harm as the preliminary signs of harm are still arising. It is interesting to note that the EEA had difficulty in identifying any cases of overregulation of a pollutant that had turned out to be benign when all the science was in. Most early warnings turn out to be legitimate. The costs of inaction are often drastically underestimated (European Environment Agency, 2013). It is still plausible that future history will show that a precautionary approach to fine plastic dust in our air, water, food and bodies was not an over-reaction. To find out for certain we will need to further improve the current array of analytical methods and support nascent initiatives to build up analytical quality control (e.g. providing analytical development exercises, inter-laboratory calibration and certified reference materials) - as is done for every other emerging contaminant that was unmeasurable at first. This will enable us to reliably determine trace amounts of fine plastic particles in environmental samples and in humans in the real world, which is needed for risk assessment. Dedicated toxicological and epidemiological studies will enable us to critically investigate the health risks of plastic particles, identify toxicological mechanisms and vulnerable population groups. Constituent chemicals in plastics, for instance bisphenol A, phthalates or brominated flame retardants, and other chemicals sorbed to plastic particles such as polycyclic aromatic hydrocarbons and PCBs, have been implicated in a variety of disease processes (Landrigan et al., 2018). The ability of microplastics to be chemical and pathogen vectors needs to be seriously considered as part of the overall assessment of microplastic safety (Vethaak and Leslie, 2016). Stakeholders including scientists should thoughtfully and systematically scrutinize all claims, policy justifications and political angles in the debate. Multiple hypotheses and viewpoints abound and so they should until new data and better knowledge emerge.

Meanwhile, it is clearly perilous to believe that the absence of evidence of risk translates into evidence for the absence of risk. Logic does not allow the current knowledge gap for plastic particle exposure and toxicology to steer the bias towards a belief that 'microplastics are safe'. What's wrong with saying that so far *'no one knows what the presence of foreign microplastic particles in our bodies, across the life course, could mean for health'*? In view of the current and projected growth in plastic particulate pollution, there is an urgent driver to find out what is actually happening, as pointed out in The Lancet Planetary Health (The Lancet Planetary Health, 2017). All the elements of post-normal science are here*: 'facts uncertain, values in dispute, stakes high and decisions urgent'* (Funtowicz and Ravetz, 1993). Human risk assessment of plastic particles is a highly complex matter that requires paying attention to how we frame the problem, communicate uncertainty, design the research, assess the input data quality and quantity, and inclusively involve stakeholders.

What can be concluded so far? *i)* The vast knowledge gap renders risk-based environmental and human health protection policy for plastic particles impossible at present, and such an undertaking will take at least a decade or two of intensive dedicated research and evaluation. *ii)* A precautionary approach is warranted to limit human exposure to plastic particles, until adequate evidence of safety emerges. The rationale is that the risk is scientifically plausible but uncertain, it is potentially serious, and could be considered '*inequitable to present and future generations'* (World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), 2005, p.14). The grounds for concern are present because the 'not safe' hypothesis is consistent with existing scientific knowledge and theories from particle and fibre toxicology, air pollution particulate studies, and nanotoxicology. Faced with two unstudied hypotheses of safe versus not safe for human health, the precautionary princìple advises us to '*suspend our judgement about which hypothesis is true because we are ignorant about that*.' (World Commission on the Ethics of Scientific Knowledge and Technology (COMEST), 2005, p.15). *iii)* The fastest way to resolve the scientific unknowns is to implement research to address today's troublesome knowledge gaps regarding human exposure, toxicological effect mechanisms and hazard data.

It is important to society to get to the bottom of this question of risk. Why? Because the world does not want to be caught off guard by another *'environmental nasty surprise'* that poses a *'potentially large-scale, long-term threat to human or ecological health'* (Howard, 2011), such as the widespread distribution of endocrine disrupting chemicals, active at low doses (Vandenberg et al., 2012). The COVID-19 virus outbreak is another particularly stark example of what happens when precaution, preparedness and guarding against logical fallacies in thinking are neglected. To avoid another 'surprise', it is of central importance to critically evaluate the quality of arguments on all sides of the debate.

Non-communicable (or chronic) diseases are now responsible for 71% of deaths globally, far out-killing infectious diseases (World Health Organization, 2018). They are on the rise and we do not fully understand why. We know however that chronic inflammation is a prelude to many chronic diseases, such as diabetes, cardiovascular and respiratory disease, and that plastic dust sometimes appears to be inflammatory (SAPEA, 2019; Vethaak and Leslie, 2016; Wright and Kelly, 2017). But that's where our current knowledge on microplastics and health wanes.

Right now we are flying blindly. This should be enough to raise more than a policy making eyebrow. Science will have to respond to the burden of proof shift that comes with microplastic safety claims that have emerged despite a lack of knowledge and information. Testing our hypotheses with real-world exposure and health effect data will be both more logical and effective than assuming risk is absent in the absence of evidence.

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