

# On the Creation of Risk: Framing of Microplastics Risks in Science and Media

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The public is concerned about plastic pollution, while clear-cut scientific evidence for an environmental risk of microplastics is absent. This contrast between incomplete scientific knowledge and public risk perception is an interesting case for investigating how “environmental risk” is transformed in science communication. This study examines how microplastics risks are framed in peer-reviewed publications and online newspaper articles, respectively. It also analyzes if the contents conveyed by the frames used in science and the media are consistent. The results show that most scientific studies (67%) frame microplastics risks as hypothetical or uncertain, while 24% present them as established. In contrast, most media articles reporting on microplastic impacts (93%) imply that risks of microplastics exist and harmful consequences are highly probable. The creation of simple narratives (journalists) and the emphasis on potentially negative impacts (scientists) contribute to this inconsistency. The transformation of an uncertain risk into an actual risk is further caused by two inconsistent risk conceptions, namely risk being the probability of a negative outcome (environmental scientists) or being the uncertainty of a negative outcome itself (public). Although the latter differs from the risks identified “objectively” by scientific methods, it allows understanding the risk perception of the public and decision-makers.

of plastic pollution is immense. In a representative survey, 87% of Europeans worry about the effects of plastics on the environment and 74% about effects on their health.<sup>[4]</sup> The concerns over this “plastic crisis”<sup>[5]</sup> have triggered a range of societal and political actions,<sup>[6]</sup> including the ban of microbeads from rinse-off cosmetics and single-use plastics bags in certain countries.

At the same time, there is in the scientific community disagreement on the relevance of the issue of plastic pollution relative to other environmental issues.<sup>[7]</sup> For microplastics in particular, some scientists have argued that their so far detected environmental levels or intrinsic toxicity are far too low to be of larger concern.<sup>[8,9]</sup> Along this line of thinking, they criticize that fellow scientists frequently exaggerate the risks of microplastics.<sup>[8,10]</sup> Feared consequences are that this exaggeration has triggered sensational media reports which, in turn, created a public misperception of the risks

## 1. Introduction

Research demonstrating the ubiquity of plastics and especially microplastics (<5 mm in size) in aquatic ecosystems has triggered a broad public debate about the (un)sustainable use and the environmental impacts of plastics.<sup>[1]</sup> As research on plastic pollution is still in its infancy, it is characterized by many open questions, knowledge gaps, and uncertainties.<sup>[2,3]</sup> While the environmental impacts are far from clear, the public awareness

of microplastics.<sup>[8,10]</sup> As a result, critics claim recent policy decisions are not supported by scientific evidence and, thus, disproportionate.<sup>[2,3,8]</sup>


The case of microplastics is interesting because it sheds light on how scientists frame environmental risks and how the media frames the issue to inform the public and shape public opinion.<sup>[11,12]</sup> As environmental issues are particularly newsworthy, mass media play a crucial role in defining risks and framing scientific knowledge,<sup>[11,13]</sup> sometimes at odds to what scientists consider most important.<sup>[11]</sup> As these discrepancies in risk framing become especially evident when communicating risk and uncertainty,<sup>[14]</sup> the area of microplastics becomes a relevant test case.

Accordingly, the aim of this study is to understand how the risk of microplastics is framed in science and the media. We analyzed peer-reviewed scientific articles and Anglophone online newspapers to address the following questions:

- 1) How is the environmental risk of microplastics framed in scientific articles?
- 2) How is the environmental risk of microplastics framed in media reports?
- 3) Is there consistency between the contents conveyed by the frames used in science and the media?

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By addressing these questions, we aim at illuminating risk controversies in scientific publications, find out how scientific knowledge as well as the associated uncertainties are presented by the media, and how scientists contribute to the media discourse.

## 2. Approach and Methods

This work draws on Entman's conceptions of "frames" and "framing" in communication and media studies.<sup>[15]</sup> He defines framing as "to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described." Thus, frames of issues or events are constructed by specific framing devices, which define problems and causes and can contain moral valuations as well as possible solutions.<sup>[16]</sup> This article concentrates on framing devices that create "problem frames" of the issue of microplastics and whether these "problem frames" convey notions of risk, threat, or other negative consequences and does not focus on moral valuations and possible solutions. Entman<sup>[17]</sup> is rather vague on his definition on "framing devices," referring to it as "choices of words or images." For Gamson and Modigliani,<sup>[18]</sup> framing devices comprise "metaphors, exemplars, catchphrases, depictions, and visual images." Taking up on this, we define "framing devices" as language or depictions used to frame issues in a certain way. As framing devices, particular words are analyzed, e.g., nouns or adjectives, phrases, metaphors, storylines, and images used to formulate a problem frame. In our understanding, problem frames refer to ways how issues are problematized through framing devices. Facts but also concerns or feelings can be building blocks of this problematization.

The first research question addresses the scientific discourse and examines whether scientific publications apply the paradigms of environmental risk assessment as framing device. The concept of environmental risk assessment, which is the guiding paradigm in (eco)toxicology, is based on the principle that the exposure to an agent, e.g., a chemical substance, must be compared to its intrinsic hazard to conclude on an environmental risk. Basically, it raises three questions: 1) What is the expected concentration the environment? (estimation of the predicted environmental concentration, PEC) 2) What effect does a substance have on organisms and at what concentration are no more effects to be expected? (estimation of the predicted no effect concentration, PNEC) 3) What is the PEC/PNEC quotient?

Thus, the first step is to assess the hazard potential of a substance on the basis of its toxicological properties (e.g., determination of adverse effects in laboratory tests) and to estimate a maximum tolerable substance concentration for an organism. In a second step, the possible exposure (concentration in the environment to which the organism is exposed) is determined and in a third step the risk is estimated based on the comparison between the hazard and the exposure.<sup>[19]</sup> The basic principle of comparing exposure to hazard applies for both, the assessment of risks of chemicals to the environment (field of ecotoxicology) as well as human health (field of toxicology).

The second research question on how the issue of microplastics is framed in the media examines the problem frames circulating in the media. Unlike the first question, the framing is not evaluated according to the paradigms of environmental risk assessment. Since this concept conveys a very specific expert understanding of risk, a broader notion of risk was needed for the media analysis. In risk literature, risk is not automatically negatively connoted, since people might decide to take a risk for potential positive outcome.<sup>[20,21]</sup> However, more often risk research deals with the anticipation or likelihood of events with negative outcomes.<sup>[21,22]</sup> Risks are often considered as an intrinsic product of scientific and technological development.<sup>[22]</sup> The media covers mainly possible negative outcomes of microplastics for human and environmental health, therefore risk here is understood as a situation or development that can lead to negative consequences.<sup>[23]</sup> This broader notion of risk necessitates different framing devices as the paradigm of environmental risk assessment in the case of question 1. Thus, narratives and interpretative frames are used. Narratives are the representation of events.<sup>[24]</sup> They consist of a certain storyline and use interpretative frames. Interpretative frames assert specific meaning to things like microplastics and to processes in which microplastics are involved, and thus offer a plausible way to understand a story or events in a certain way.<sup>[25]</sup>

Finally, question 3 compares what the problem frames applied in science and the media convey to assess whether they are consistent. This is to test the assumption that a certain risk framing by environmental scientists, that is, an exaggeration of the actual risks of microplastics, is taken up in the media representation of the issue.

### 2.1. Analysis of Scientific Papers

In total, 464 peer-reviewed, scientific articles were selected from journals frequently publishing studies on microplastics in the aquatic environment to address the first research question. The journals were selected based on their impact in the field of environmental sciences as well as the frequency of publications on microplastics. Articles were obtained using the search term "microplastics" on the respective journal homepage from the journals *Aquatic Toxicology* (7), *Biology Letters* (1), *Chemosphere* (19), *Ecotoxicology and Environmental Safety* (3), *Environmental Pollution* (105), *Environmental Research* (8), *Environmental Science & Technology* (71), *Environmental Toxicology and Chemistry* (13), *Marine Pollution Bulletin* (170), *Science of the Total Environment* (35), *Scientific Reports* (19), and *Water Research* (13) and included original research papers as well as reviews. In order to focus on the debate on microplastics risks, papers mainly investigating macroplastics were excluded from the corpus. Furthermore, editorial notes or viewpoints were excluded to focus on primary not secondary risk framing. The articles cover the years 2006 until January 2018, most articles are from 2017 (175). Using the software MAXQDA Analytics Pro 2018, papers were categorized depending on the framing of risk in the introduction, discussion, and conclusion sections. The framing was analyzed by identifying particular key words, phrases, and images used to define and evaluate the problem.<sup>[17]</sup> Studies stating that an environmental risk is

**Table 1.** Framing devices used in studies stating an environmental risk of microplastics. Examples do not represent original quotations but reflect typical formulations.

Framing device	Examples
Value adjectives	microplastics are dangerous, ...are harmful, ingestion of microplastics is harmful, microplastics have deleterious impact on
Active verbs	microplastics pose a risk to, microplastics threaten the environment, represent a threat, harm the environment
Reference to knowledge	pose an environmental threat primarily because [listing of reasons]..., are known to cause impacts
Reference to conclusions from previous studies	microplastics are recognized as threat, considered a major threat
Missing contextualization with regard to hazard and exposure	microplastics can cause adverse effects, including ... [listing of various effects]. microplastics pose an environmental risk primarily because organisms may ingest microplastics

established, for instance by using key phrases such as “microplastics pose a risk,” were classified in the category “risk.” Studies defining the risk as hypothetical using key phrases such as “microplastics may pose a risk” were classified in the category “hypothesis,” for an overview of the framing devices see **Tables 1 and 2.**

## 2.2. Media Analysis

For the media analysis conducted to address question 2, five Anglophone online newspapers with a large readership and a broad political spectrum were selected: The Guardian (UK), The New York Times (USA), and HuffPost (UK + USA) as quality newspapers and The Sun (UK) and USA Today as tabloids. A google search with the name of the respective newspaper and one of the following keywords “microplastics,” “plastic pollution,” “plastics,” “plastic particle,” “microbeads,” and “microfiber” was conducted. The keywords “plastics” and

**Table 2.** Framing devices used in studies which frame the environmental risk as a hypothesis. Examples do not represent original quotations from the investigated scientific articles but reflect typical formulations.

Framing device	Examples
Attributive adjectives expressing uncertainty	potential risk, possible risk
Modal verbs expressing uncertainty	may pose a risk, could represent a risk
Reference to ignorance/knowledge gaps	information about effects is limited, little is known about the ecological consequences, effects are poorly understood
Reference to hypothesis from previous studies	it has been hypothesized that microplastics may pose a risk, it is assumed that...
Reference to a pending risk assessment	to evaluate the hazard of microplastics within a risk assessment context
Contextualization with regard to hazard and exposure	experiments using high unrealistic concentrations, link at environmental concentrations

“plastic pollution” were used to identify also articles, which use synonyms for microplastics like pellets, fragments, and spherules. In total, 186 media articles from The Guardian (45), The Sun (14), New York Times (45), USA Today (18), and HuffPost (66) were found and selected for the analysis. The corpus of articles covers the time from 2009 to July 2018. MAXQDA Analytics Pro 2018 was used for the content analysis. With content analysis based on the assumption of grounded theory,<sup>[26]</sup> several narratives were identified, which, in their broad storyline, frequently occur in the articles.

To further analyze the problem frame, the thematic context and the interpretative frames were examined that are conveyed with regard to the risks of microplastics. Therefore, articles reporting on impacts of microplastics were grouped into four categories (“level of concerns”) based on the severity of the negative outcomes communicated: 1) factual representation of scientific findings without interpretative frames, 2) implying negative impacts on the environment, 3) linking microplastics to the human food chain, and 4) linking to negative consequences for human health. It was further analyzed if scientific uncertainty is addressed in the reports on negative outcomes.

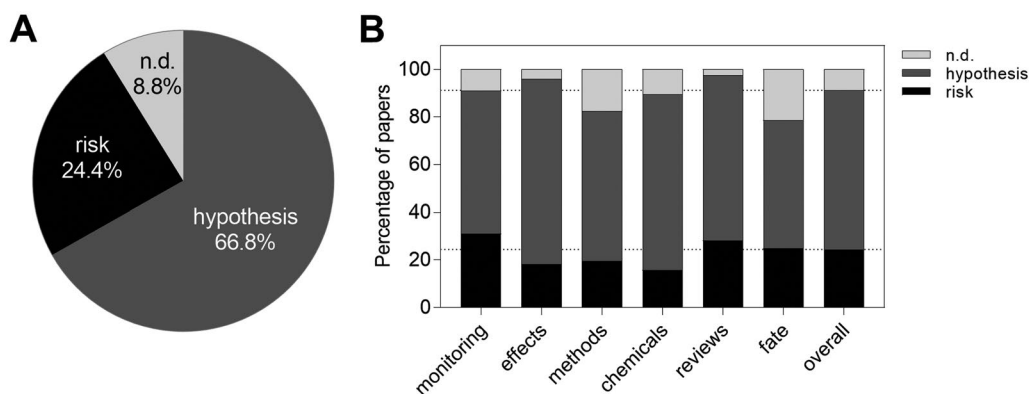
## 2.3. Analysis of Scientific Contributions in Media Reports

In order to compare what the problem frames applied in science and the media convey (question 3), a closer look was taken at the contributions of scientists and scientific studies to the media reports. It was analyzed whether the media reports refer to specific scientific findings and statements by particular scientists. The latter were analyzed by assessing the risk framing and the communication of uncertain scientific knowledge. We further analyzed the scientific studies that are covered most frequently in the media articles. We checked for the respective “level of concern” addressed in the media reports covering these scientific studies and the risk framing in the scientific articles. It was also examined which hypotheses about environmental impacts are mentioned in the scientific articles. Finally, the risk framing was checked in press releases and further public relations activities related to the scientific articles.

## 3. Results and Discussion

### 3.1. Risk Framing in Scientific Studies

In our analysis of scientific studies, we refer to the (eco)toxicological risk conception whereby risk is determined by exposure and hazard. We included papers dealing with both the characterization of exposure and hazard in the analysis. Of the 464 articles examined, the majority (38.2%) addresses the abundance of microplastics in environmental matrices, wastewater as well as biota. About a quarter (27.2%) deals with the ingestion, uptake, and effects of microplastics on various organisms, in particular aquatic invertebrates and fish. The remaining studies are on methodological issues (11.0%), (de)sorption and transfer of plastic-associated chemicals (8.2%), reviews of the current knowledge (8.4%), deal with the environmental fate of



**Figure 1.** Framing of the environmental risk of microplastics in scientific studies A) and as a function of research topics. B) For each topic, the percentage distribution of papers across the different risk categories is given. The dotted lines indicate the overall distribution across the risk categories: n.d. = not discussed, 8.8%; risk = 24.4%; hypothesis = 66.8%,  $n = 464$ .

microplastics (6.0%) as well as further topics such as policy or perception (1.1%).

Since all studies aim at characterizing the environmental impacts of microplastics, the majority of articles are structured in a similar way. In the introduction as well as discussion and conclusion sections, authors usually refer to the current state of knowledge, which is presented with different emphases. Within this representation, most of the studies refer to the environmental risk of microplastics, either framed as a hypothesis, that is, a potential risk to be investigated, or as an established risk based on existing scientific evidence. Interestingly, none of the studies states that microplastics do not pose an environmental risk. In most cases, the risk is framed as a hypothesis (66.8%). However, a substantial part of studies (24.4%) states that microplastics pose an environmental risk. Only a small part (8.8%, “n.d.”) does not refer to risk (Figure 1A).

The risk framing partly depends on the specific research topic. The authors of “monitoring” studies more frequently state a risk (31.1%, Figure 1B) compared to the overall distribution (24.4%). Authors of “effect” studies (including ingestion, uptake, and toxicity) rather point to risk as hypothetical (77.8% vs 66.8% overall distribution). Studies on “methods” or “fate” of microplastics more often do not mention environmental risk at all (“methods” 17.6%, “fate” 21.4% vs 8.8% overall distribution). The higher amount of review articles stating an environmental risk (28.2%) cannot be attributed to a specific topic, as these studies mainly summarize monitoring, fate, and effect studies in one article.

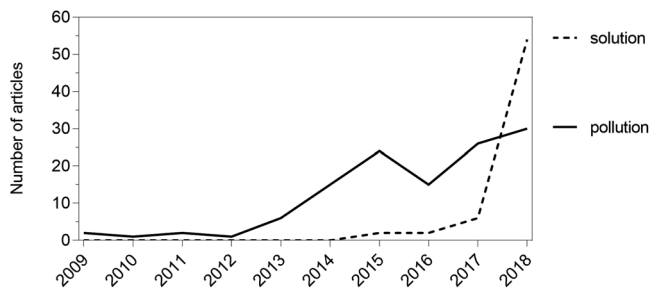
Studies framing microplastics as an established environmental risk use the words and key phrases summarized in Table 1. Typical framing devices are value adjectives such as “dangerous,” “harmful,” or “deleterious” or nouns such as “threat.” Others address the risk directly using active verbs (“microplastics pose a risk”) or refer to previously established knowledge (“microplastics are considered a major threat”). Finally, authors refer to the available evidence on hazards, either indirectly (“microplastics are known to cause impacts”) or by listing effects on different organisms demonstrated in previous studies. Interestingly, the aspect of actual exposures is not mentioned in those studies. In contrast, two third of the studies from the category “risk” (67.3%), use the occurrence of

microplastics in the environment, their persistence, and ingestion by organisms as argument, suggesting that risk is framed as a matter of exposure, only.

Even though all of these studies state an environmental risk, there are also cases in which other statements in the respective articles contradict this framing. These studies denote microplastics as an environmental risk, but at the same time mention that the impacts to organisms or ecosystems are unknown. This conflicting argumentation in the sense of the (eco) toxicological risk concept suggests that the authors may have a different understanding of risk, even if it is only expressed implicitly.

Studies classified in the category “hypothesis” also refer to the environmental risk but frame the issue as uncertain and insufficiently investigated. Typical elements to express uncertainty (Table 2) are adjectives such as “possible” or “potential” as well as modal verbs preceding the formulation (“may pose a risk”). Other authors refer to knowledge gaps (“little is known about the ecological consequences”) or to the risk assessment which is not yet conclusive. Adverse effects on organisms are classified in relation to environmental concentrations, that is, a direct comparison of hazard and exposure is made. Furthermore, authors refer to hypotheses made by others (“it has been hypothesized that microplastics may pose a risk”).

In summary, the majority of studies typically frame the risks of microplastics as a complex and uncertain issue. However, there is also a smaller fraction of studies, which frames the risk as established. Either this framing is done intentionally, possibly in order to attract attention motivated by hypercompetitive publication practices,<sup>[27]</sup> or for other (unintentional) reasons, e.g., lack of proficiency in English or ignorance of the concept of environmental risk assessment. The fact that the authors of monitoring studies more frequently state an environmental risk indicates that not all disciplines are familiar with the concept. Since the concept of risk as a whole is complex and multi-dimensional, there may also have been confusions between the professional and the colloquial meaning of the term.<sup>[28]</sup> Further understandings of risk, such as the term “elements at risk”<sup>[29,30]</sup> describing objects (e.g., ecosystems) potentially adversely affected, could also lead to conflicting interpretations in this context.



**Figure 2.** Number of published media articles on (micro)plastics per year addressing two main topics,  $n = 186$ .

### 3.2. Representation of Microplastics in the Media

The 186 media articles selected for the analysis can be classified into two main categories: 1) articles dealing with (micro)plastic pollution and associated environmental and health problems (122, 65.6%) and 2) articles dealing with solutions in terms of plastic recycling, zero waste stores, ban, and replacement of single use plastics as well as reduction of plastic use (64, 34.4%). The number of articles dealing with pollution increased from 2009 to July 2018, having a first peak in 2015. This appears to be connected to the detection of microplastics in the Laurentian Great Lakes and the ban of microbeads in rinse-off cosmetics in the USA in 2015 as most of the articles report on these topics. The high number of articles on solutions in 2018 is dominated by debates of banning and replacing plastic straws and other single use items, topics like the EU proposal for a ban of single-use plastic products and China's import ban of plastic waste for recycling (Figure 2).

Since the focus of the media analysis is on the framing of the environmental risks, the share of articles dealing solely with solutions was not further analyzed. The 122 articles on plastic pollution cover the following topics: occurrence of microplastics in the environment (e.g., oceans, lakes, rivers, ice, 49.2%), microbeads in personal care products (27.1%), microplastics in food, beverages, and drinking water (15.6%), microfibers in clothes and laundry (7.4%), and microplastics in the air (0.8%). In these articles, the framing of the problem of plastic pollution was further assessed.

#### 3.2.1. Narratives as Problem Frames

Media reports use three main narratives to create the problem frame and shape the discourse:

Narrative 1: Microplastics are present in the environment in large numbers.

The first narrative illustrates the overall scale of (micro)plastic pollution in the environment. One way of communicating this is the use of large numbers, including the following images and analogies:

“500 times more than there are stars in the galaxy” (HuffPost)<sup>[31]</sup>

“five trillion pieces of microplastic in the world's oceans and the equivalent of one rubbish truck of plastic waste is being added to the sea every minute” (The Sun)<sup>[32]</sup>

Large numbers add weight to a statement, imply a “huge” problem and elicit a state of urgency, since laypersons are usually not able to fully comprehend the implications of such large numbers.<sup>[33,34]</sup> Furthermore, images which demonstrate the extension of the phenomenon are created by terms such as “smog” or “nebulous swarm of pollution.”

“You can rid your mind of conceptions of “trash islands” or “garbage patches” and visualize the global spread of microplastic in the ocean the same way we could literally see smog over our cities.” (HuffPost)<sup>[35]</sup>

“Like the North Pacific garbage patch, the one in the southern part of the ocean is a nebulous swarm of pollution made up of tiny plastic fragments, known as microplastics, which can be hard to see with the naked eye and even harder to clean up.” (HuffPost)<sup>[36]</sup>

Narrative 2: Microplastics are present in food and beverages for human consumption.

The second narrative comprises microplastics in food and beverages for human consumption. Here, several scientific findings on microplastics in beer, water, honey, sugar, salt, fish, and shellfish contribute as parts in the mosaic of this narrative. These articles build up a narrative according to which it is likely that humans are constantly consuming microplastics.

“The scale of global microplastic contamination is only starting to become clear, with studies in Germany finding fibers and fragments in all of the 24 beer brands they tested, as well as in honey and sugar.” (The Guardian)<sup>[37]</sup>

“Scientists at Ghent University in Belgium recently calculated that shellfish lovers are eating up to 11 000 plastic fragments in their seafood each year. We absorb fewer than 1%, but they will still accumulate in the body over time.” (The Guardian)<sup>[38]</sup>

“Sea salt around the world has been contaminated by plastic pollution, adding to experts' fears that microplastics are becoming ubiquitous in the environment and finding their way into the food chain via the salt in our diets.” (The Guardian)<sup>[39]</sup>

The narrative of microplastics in food is strongly and directly linked to the abundance of microplastics in natural environments. The storyline is that microplastics are ubiquitous in rivers, lakes, and oceans or the atmosphere and, therefore, contaminate food.

“Tiny plastics known as ‘microfibres’ may very well be floating around in your food. They are released when you wash your clothes, flow into rivers and oceans and can end up in seafood.” (HuffPost)<sup>[40]</sup>

“THE shocking amount of plastic we eat and breathe in has been revealed after tests were carried out on shop-bought fish. An investigation found food exposed on open counters in supermarkets were contaminated with potentially dangerous particles that float in the air.” (The Sun)<sup>[41]</sup>

Narrative 3: Microplastics contain toxic chemicals which are passed along the food chain.

The third narrative is that microplastics act like “a sponge” adsorbing toxic pollutants or containing chemicals like plasticizers or flame retardants.

“Scientists know that both plastics and microplastics act as chemical sponges attracting toxins dissolved in water.” (HuffPost)<sup>[42]</sup>

Once microplastics are eaten by sea life, these chemicals are accumulating in the bodies of the organisms and, thus, in the human food chain.

“The beads have chemicals contained in the plastic and also collect on their surfaces other pollutants from the waters, including DDT and polychlorinated biphenyls (PCBs), which are highly toxic to living organisms. The particles are then ingested by fish, amphibians, and other small animals, which mistake the microbeads for food, and then become part of the food chain as larger animals eat the smaller ones. The problem is massive.” (HuffPost)<sup>[43]</sup>

“The plastics are then consumed by marine life; research has suggested that the harmful chemicals can be passed along the food chain to any animal—including humans—that eats seafood.” (The New York Times)<sup>[44]</sup>

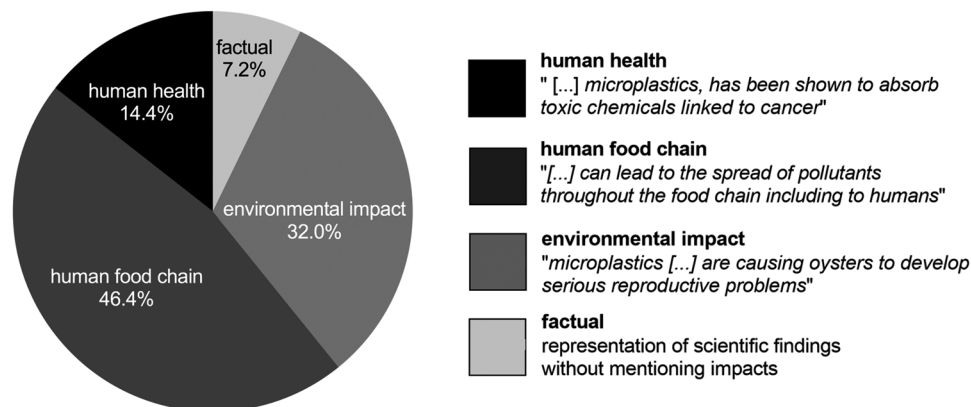
In addition, the articles do not differentiate between pollutants adsorbing to and chemicals leaching from plastics. Moreover, other exposure pathways of these chemicals (e.g., contaminated food) do not play a role as this would change the focus of the storyline.

All narratives have in common that the problem of microplastic pollution is primarily framed as a matter of exposure, that is, the presence of microplastics (including the associated chemicals) in all environmental compartments, in wildlife, and in human food. By addressing the human food supply and using adjectives such as “harmful,” “toxic,” or “dangerous” to depict microplastics and associated

chemicals, a threat to human health is established as a likely consequence.

### 3.2.2. Representation of Microplastics Risks

Out of 122 plastic pollution articles, the articles which describe some kind of impact of microplastics on the environment and/or humans were analyzed (97 articles), while those articles dealing mainly with plastic pollution (macroplastics) in general were not considered further (25 articles). The 97 articles which address any kind of impacts primarily report on the abundance of microplastics in the environment (77.3%) and human food (18.6%). Only 4.1% primarily address impacts or negative consequences, including effects on biota and ecosystems, the transfer of microplastics and associated chemicals along the (human) food chain as well as exposure and effects on humans. Even though negative consequences are not the main topic of most of these articles, all point to the possible consequences of microplastic pollution. For the analysis, we focused on the thematic contexts as well as interpretative frames describing the consequences of microplastic pollution rather than on whether the paradigms of environmental risk assessment (exposure compared to hazard) were applied. In doing so, we sorted the 97 articles along different levels of concern according to the respective context of the media report. In the literature on risk communication, the communication of environmental risks such as the abundance and effects of microplastics in the environment is believed to provoke less concern among the public than risks for human health, which directly address the personal level.<sup>[45–47]</sup> Accordingly, the 97 articles were categorized into the following categories addressing four different “levels of concern” (Figure 3): 1) factual representation of scientific findings without further interpretations or the use of judgmental terms (7.2%), e.g., reports on microplastics in the environment and their ingestion by organisms and 2) articles implying negative impacts on the environment (32.0%), often using nouns such as “hazard” and “threat,” as well as adjectives like “toxic,” “bad,” “dangerous” and statements of experts who “warn” or are “worried” or “concerned.” 3) The third level comprises articles which make the link to the human food chain, in which toxic chemicals



**Figure 3.** Categorization (“levels of concern”) of how the risk of microplastics is framed in media articles,  $n = 97$ . Levels of concern: 1 = factual representation, 2 = environmental impact, 3 = human food chain, 4 = human health. Sources of quotes: human health,<sup>[48]</sup> human food chain,<sup>[49]</sup> and environmental impacts.<sup>[50]</sup>

or microplastics could accumulate and finally reach the human (46.4%). 4) Articles of the fourth level comprise issues of level two and three and in addition speculate about consequences for human health by making links to cancer or other diseases which can be caused by microplastics and the associated chemicals (14.4%). Thus, the categorization is based on the principle that level two only comprises articles, which refer to the environmental impact. Level three comprises articles, which address the human food chain and may also deal with environmental impacts. Articles of level four make a link to human health, and may also cover the human food chain and environmental impacts. In summary, 92.8% of media articles imply that risks of microplastics exist and harmful consequences are highly probable.

### 3.2.3. Scientific Uncertainty in the Media

We further analyzed how the reports deal with scientific uncertainty. In half of the 97 articles (47.4%), microplastics are not addressed in terms of uncertain scientific knowledge and ignorance but rather as toxic, posing a risk to the environment and human health. Thus, scientific hypotheses about the impacts of microplastic pollution are communicated as scientific facts:

“Environmental experts say that microplastics are pernicious to wildlife. [...] Not only do microplastics mimic plankton, an important food source for fish and seabirds, but they also absorb toxins commonly found in polluted waters, like PCBs, pesticides, and flame retardants. The plastic particles slip easily into the food chain, contaminating wildlife and, possibly, humans.” (*The New York Times*)<sup>[51]</sup>

This framing corresponds to a general pattern observed in media reports on scientific findings and is referred to as “concept of popularization.”<sup>[11]</sup> Journalists usually pursue to tell a story that is recognizable to their audience.<sup>[12]</sup> As uncertainties would weaken the story, popularization tends to reduce complexities of scientific knowledge and provide simple explanations of risks in order to deliver clear messages. As a consequence, scientific knowledge appears more certain than scientists consider it to be.<sup>[52]</sup>

The other half of the articles (52.6%) addresses uncertainty about the environmental impacts of microplastics in some way. However, articles that mention uncertainty and ignorance frequently establish interpretative frames suggesting it is very likely that microplastics are toxic or dangerous:

“The data on the impact of microplastics on humans is still lacking, but research on animals has suggested the particles can cause cancer, hormone disorders, and other problems when they release chemicals during digestion. Plastic isn’t biodegradable either, so scientists fear it will continue to break down into smaller fragments that can pierce cells and travel through lymph nodes and other organs.” (*HuffPost*)<sup>[53]</sup>

These interpretative frames lack contextualization in regard of realistic exposure levels and link to negative health effects. Thus, the implicit message is that it is just a matter of time

until the risk of microplastics will be established and not that it is a question of whether or not microplastics are toxic. The uncertainty rhetoric is further used as a device to call for more research.<sup>[11,52]</sup>

In summary, the framing of the media articles implies that harmful consequences are highly probable. The image is constructed as follows: 1) microplastics are small, synthetic, and ubiquitous in the environment in large numbers, 2) microplastics harm wildlife, 3) microplastics contaminate human food, therefore, everyone is exposed, 4) microplastics transport harmful chemicals along the food chain including to humans. This framing has many researchers led to accuse the media of sensational reporting as it does not correspond to the scientific estimations and reflects a particular position.<sup>[6,8]</sup> Scientists commonly denote media stories as biased that present risks as more or less hazardous than mathematical estimates would justify.<sup>[54]</sup> Little attention is paid to the fact that the public comprehends the term risk differently and not in the sense of its (eco) toxicological use. In risk perception research, it is customary to refer to risk as a situation or development that may result in negative outcomes,<sup>[23]</sup> or, in other words, an event where the outcome is uncertain.<sup>[55]</sup> Contrary to this use, environmental scientists speak of risk when negative consequences occur with a known or estimated probability.<sup>[21,23]</sup> Certainly, the representation of microplastics risks in the media is not only due to this inconsistency as “scary” headlines and the focus on human health is also a method to provoke attention (e.g., clickbait),<sup>[56]</sup> but should be taken into account especially in the communication of scientific results.

## 3.3. Contribution of Science to Media Reports

In order to understand if the risk framing in science is taken up in the media representation, we further analyzed those scientific studies that are covered in the media articles. In 70.2% of the 122 articles reporting on pollution, one or more scientific studies are cited and, therefore, play a significant role for forming a narrative. In many cases, an article does not cover one scientific study alone but creates a richer story by combining different findings. Overall, 63 peer-reviewed studies are cited in the selected media reports. Some findings of scientific studies are repeatedly quoted in different articles, always conveying the same message. Furthermore, most articles arrange different expert statements and observations. The experts are either environmental scientists, members of non-governmental organizations or international governmental organizations, industry spokespersons, or politicians. By doing so, claims of the articles are asserted as credible and legitimate since they are not presented as an interpretation of the journalist, but in a more “objective” way through the respective experts.<sup>[54]</sup>

### 3.3.1. Statements from Scientists

In most of the articles (47, 62.0%), scientists have a direct say, that is, they are quoted with literal speech. These articles contain a total of 138 different quotes from scientists, some of

**Table 3.** Type of statements on possible environmental impacts of microplastics. Examples do not represent original quotations but reflect typical statements.

	Type of statement	Examples
Hypothesis (37.3%)	reference to knowledge gaps	We don't know what the impacts are, and we need to find out.
	stating a potential risk	Given their ubiquitous abundance, microplastics have become a potential risk to the environment.
Risk (5.1%)	stating an established risk	We have the evidence that microplastics do cause harm.
No risk (5.1%)	contextualization of findings	At current exposure levels, there is no evidence of harm to humans.
Speculative statements (52.5%)	link to human exposure/food	If we breathe in microplastics, they could deliver chemicals to our lungs. Plastics are in our beer, in our water, in our seafood, and in our salt.
	link to effects on humans	Plastics can deliver synthetic chemicals into our bodies that are connected to increases in certain kinds of cancer.
	use of judgmental terms	We are worried ingestion of microplastics could result in toxicological harm. We fear that plastic is taken into the gills of fish. It is quite likely that we will find effects.
	drawing analogies	If it happens in one species, it can also happen in other species.

which are cited more frequently in different articles. In most of the cases, the statements are on the (potential) impacts on humans and the environment (59, 42.8%). Further statements are on the environmental abundance (38, 27.5%), possible sources (15, 10.9%), and on solutions (23, 16.7%).

In the 59 statements about impacts, scientists mostly refer to scientific uncertainty but do so in different ways (Table 3). On the one hand, the risks of microplastics are stated as uncertain due to a lack of knowledge or as an open question (22 “hypothesis” statements, 37.3%), which can also be considered as a call for more research.<sup>[52]</sup> On the other hand, there are also statements that do not refer to the environmental risk in a toxicological sense but might trigger interpretations that exposure to microplastics is harmful by using judgmental terms or speculating about negative (health) effects (31 speculative statements, 52.5%). However, there are also statements in which scientists take a clear position, that is, stating that an actual risk exists (3, 5.1%) or does not exist (3, 5.1%) based on the available evidence. Overall, 59.3% of statements made by scientists are related to human exposure.

The impacts mentioned in the statements are hardly explained in a scientific risk context, comparing hazard and exposure. Statements made by scientists in the media are, therefore, mainly used to describe and speculate about the uncertain consequences of microplastic pollution. These communications are particularly interesting, as unintentional confusion may occur between two different risk concepts. In the scientific context, risk is defined as a probability of a negative event

happening.<sup>[21]</sup> The uncertain negative outcomes communicated thus only address scientific hypotheses that do not yet allow any statement to be made about the probability of occurrence of the risk. Contrary to the scientific concept, media frames refer to risk as an event where the outcome is uncertain. By focusing on speculations about negative consequences, the communicated risk is amplified and dramatized. These findings suggest that statements about scientific hypotheses and uncertainties are losing hypothetical character in the media and support the narrative of negative consequences of microplastics.

### 3.3.2. Media Coverage of Scientific Articles

To assess if scientific studies that state an environmental risk receive higher media coverage, we took a closer look at the most frequently discussed studies. Of the 63 studies cited in total, eleven are cited more than three times in different media articles. The topics of these contributions can broadly be grouped into studies that investigate or model the presence of (micro) plastics in the environment (global abundance, 6 studies), microplastics in seafood (3 studies) as well as on effects and sources (1 study each) (Table 4). The “levels of concern” (as elaborated in Section 2.2.2.) expressed in the respective media articles differ slightly depending on the topic of the cited scientific study. Overall, scientific articles reporting on global abundance are cited more often in media articles that do not mention environmental impacts and therefore are not assigned to any level of concern. Scientific contributions on microplastics in seafood are more likely to be covered in media articles communicating a higher level of concern (levels 3 and 4) (Table 4). The topics addressed in the scientific studies support parts of the media narratives, but the original risk framing in the studies is inconsistent to the framing in the media as none of the studies point to an established environmental risk. The risk is either framed as hypothetical (7 studies) or the studies do not refer to the environmental risk at all (4 studies). Therefore, an exaggeration of risks in scientific contributions does not readily contribute to the risk frame in the media or to higher media coverage of the article.

To further trace the causes for the overestimation of risks in media reports, we took a closer look at the hypotheses made about the environmental impacts in the respective scientific articles. In addition to the ubiquitous abundance of microplastics, which is highlighted in all scientific articles, eight refer to chemicals sorbed to microplastics, and five address the transfer of microplastics via the food chain. In two articles each, a connection between microplastics and human health is made. These impacts are consistent with the impacts described in the media (see Section 2.2.). While these impacts usually only play a minor role in the scientific articles and are formulated as hypothetical, they circulate in the media as prominent facts used to depict the risk.

We further wanted to find out at which point scientific hypotheses are turned into media “facts.” Other studies have shown that the media coverage of scientific articles is usually not related to content or how results are presented, but to the publication of a press release or other public relations activities of the scientists.<sup>[54,68]</sup> As press releases are often adopted



**Table 4.** Most-cited scientific studies on (micro)plastics in media articles. Media articles were classified according to different “levels of concern” (1 = factual representation, 2 = environmental impact, 3 = human food chain; 4 = human health).

Scientific study	Times cited	Topic	Classification of media articles according to “levels of concern” (n.d. = impacts not discussed)				
			1	2	3	4	n.d.
Jambeck et al. (2015) <sup>[57]</sup>	19	(Global) abundance (plastics)	10.5%	15.8%	26.3%	10.5%	36.8%
Eriksen et al. (2013) <sup>[58]</sup>	18	(Global) abundance (microbeads)	0%	33.3%	50.0%	5.6%	11.1%
Eriksen et al. (2014) <sup>[59]</sup>	13	(Global) abundance (microplastics)	0%	30.8%	53.8%	0%	15.4%
Geyer et al. (2017) <sup>[60]</sup>	9	(Global) abundance (plastics)	0%	11.1%	22.2%	0%	66.7%
van Cauwenberghe et al. (2014) <sup>[61]</sup>	8	Presence in seafood	0%	12.5%	62.5%	25.0%	0%
Browne et al. (2011) <sup>[62]</sup>	7	(Global) abundance (microfibers)	14.3%	14.3%	14.3%	14.3%	42.9%
Hartline et al. (2016) <sup>[63]</sup>	7	Sources (microfibers)	14.3%	14.3%	42.9%	14.3%	14.3%
Rochman et al. (2015) <sup>[64]</sup>	7	(Global) abundance (microbeads)	0%	28.6%	42.9%	0%	28.6%
Rochman et al. (2015) <sup>[65]</sup>	5	Presence in seafood (microfibers)	0%	20.0%	40.0%	20.0%	20.0%
Hall et al. (2015) <sup>[66]</sup>	4	Effects on marine organisms	0%	0%	75.0%	25.0%	0%
Lusher et al. (2013) <sup>[67]</sup>	4	Presence in seafood	0%	0%	75.0%	0.0%	25.0%

with only a few changes, scientists are attributed a powerful role in putting risks on the media agenda.<sup>[54]</sup> Therefore, we took a closer look at press releases and further public relations activities that accompanied the scientific publications. Interestingly, the lead authors of five of the most cited papers promote their work by engaging in various public activities beyond press releases, including participation in campaigns, involvement in nongovernmental organizations, collaboration with activists, and publication of policy briefs. Through these activities, scientists position themselves in the discourse, support specific policy recommendations and set research agendas. In this context, communications about the environmental risk of microplastics are framed in accordance with the discourse in the media, as the following example from a policy letter shows:

“Growing scientific evidence indicates that synthetic plastic microbeads (hereafter, microbeads) are a threat to the environment and should be banned from all personal care products. Microbeads pollute the environment, adding to the increasing abundance of microplastic debris. Too small to be efficiently filtered by wastewater treatment processes, microbeads are found in aquatic habitats and fish. Microplastic debris, and its inherent cocktail of chemical pollutants, has been found in the stomachs of hundreds of species of wildlife. The ingestion of microplastic may cause bioaccumulation of hazardous chemicals and adverse health effects in wildlife and people.”<sup>[69]</sup>

This framing involves a clear argumentation chain regarding the sources of microplastics, reduce complexities, and structure the problem with the aim of making it understandable and manageable for decision-makers.<sup>[1]</sup> At the same time, an uncertain risk has been transformed into an actual risk caused by two inconsistent risk conceptions, namely risk being the probability of a negative outcome (science) or being the uncertainty of a negative outcome itself (public). However, we cannot say whether this happens intentionally or unintentionally at this point.

Overall, our results suggest that the presentation of microplastics risks in the media cannot be attributed solely to scientists overstating risks in their scientific publications, nor to journalists exaggerating scientific results in order to create sensational media reports. The transformation is also based on conflicting risk concepts, which are implicitly referred to when information about the risk is transferred. The need to create simple narratives (journalists) and the emphasis on potentially negative effects (scientists) further amplify this discrepancy. In addition, the public is dependent on communication about hypothetical events and threats, if scientists do not provide conclusive answers. The framing of observations and predictions in risk concepts is thus also a product of communication.<sup>[70]</sup> Although this framing can differ significantly from the risks identified “objectively” by scientific methods, it allows an understanding of the relevance of individual and collective values, feelings and perspectives, and their influence on the risk perception of the public and decision-makers.<sup>[71,72]</sup>

## 4. Conclusions

This study investigates how the environmental and human health risks of microplastics are framed in the scientific literature as well as media reports. By addressing the following questions, we have shown discrepancies in that risk framing and shed light on how science contributes to the media discourse:

1) How is the environmental risk of microplastics framed in scientific articles?

The majority of scientific articles frame the issue as a new research field with many open questions, knowledge gaps, and uncertainties. These articles refer to the (eco)toxicological risk as hypothetical, also pointing to the need for more research. Despite these uncertainties, a substantial part of articles takes a clear position and communicates that a risk exists. The reasons for this discrepancy might include unawareness of the concept of environmental risk assessment, the use of other risk concepts, possibly based on colloquial meaning, language barriers, and adoption of media frames. A role can also play the pressure to succeed in a hypercompetitive publication ecosystem as well as volatile working environments with limited contracts and increased competition for research funding.<sup>[73]</sup>

2) How is the environmental risk of microplastics framed in media reports?

The media presents microplastics mostly as a serious threat to the environment and human health. The image is constructed as follows: 1) microplastics are small, synthetic, and ubiquitous in the environment in large numbers, 2) microplastics harm wildlife, 3) microplastics contaminate human food, therefore, everyone is exposed, 4) microplastics transport harmful chemicals along the food chain including to humans. Although the risk is mainly established by the omnipresence of microplastics (i.e., exposure and not by hazard), the framing of the media articles implies that harmful consequences are very probable. Thus, the likelihood of harmful consequences and knowledge gaps regarding the consequences are not presented in a balanced way.

3) Is there consistency between the contents conveyed by the frames used in science and the media?

Our results show that the media most frequently cover articles of scientists that are engaged with public relations. While the risk of microplastics is framed as hypothetical in most scientific studies, scientific statements are used to emphasize potential negative impacts in media articles, which support the narratives transported by the media. These narratives trigger public concerns, e.g., about microplastics in food, as first surveys show.<sup>[74]</sup> In this regard, an uncertain risk has been transformed into an actual risk, which is also caused by two inconsistent risk conceptions, namely risk being the probability of a negative outcome ((eco)toxicology) or being the uncertainty of a negative outcome itself (public). Although the latter differs significantly from the risks identified “objectively” by scientific methods, it allows understanding the risk perception of the public and decision-makers. Especially in times of “fake news”, a balanced discussion of scientific evidence is important and should play a role to inform the public debate and prevent that certain issues are dramatized and consequently might distract attention from other important issues.

For example, as our media analysis has shown, the debate on health effects of plastics centers around microplastics, while chemical exposure from the general use of plastics, such as food contact materials, is neglected, although constituting the main exposure pathway.<sup>[3]</sup> However, measures such as the ban on microbeads, which has probably also been induced by the media debate, are not disproportionate, as critics have claimed, but should be seen as precautionary, no-regret measures or as the very first steps along the long way to tackle the unsustainable use of plastics comprehensively.

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## Conflict of Interest

The authors declare no conflict of interest.

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