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Conversational AI Tools for Environmental Topics: A Comparative Analysis of Different Tools and Languages for Microplastics, Tire Wear Particles, Engineered Nanoparticles and Advanced Materials

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Abstract: Artificial intelligence gained a surge in popularity through the release of conversational artificial intelligence tools, which enable individuals to use the technology without any prior knowledge or expertise in computational science. Researchers, content writers, as well as curious minds may use these tools to investigate any topics in question. Environmental topics, as one of the current public concerns, are covered by many different kinds of media, indicating a broad public interest. To assess the possibility of using these tools in environmental-related content writing or research, we tested the capabilities of conversational artificial intelligence tools on selected environmental topics. In particular, we tested different tools (ChatGPT, Microsoft Bing, Google Bard) and different languages (English, Spanish, Korean, German, Turkish and Chinese) via using selected questions and compared the answers with each other. Our results suggest that conversational artificial intelligence tools may provide satisfactory and comprehensive answers; however, we found some of the statements debatable and texts still need to be reviewed by an expert. Selected tools may offer specific advantages, such as providing references, although certain issues may need to be checked for each tool. The usage of different languages may provide additional points within the content; however, this does not necessarily imply that these new facets arise solely from utilizing different languages, since new aspects may also be attributed to the 'randomness of the generated answers'. We suggest asking the same question several times as the tools mostly generate random answers each time, especially for ChatGPT, to obtain a more comprehensive content.

Keywords: microplastics; ENMs; AI Tools; ChatGPT; Bing; Bard; language

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1. Introduction

Recent developments in conversational artificial intelligence (AI) tools attracted significant attention from both institutions and individuals. Since these tools provide an interactive and dynamic conversational experience on a limitless range of topics, they can be used by anyone without prior knowledge of coding, making them easily accessible. These tools rely on large language models (LLMs) that are built on massive amounts of text and are able to process and generate text [1,2]. They can be used in various application areas including scientific research and content creation. van Dis et al. (2023) highlighted conversational AI as a game-changer for science, stating that it may revolutionize research practices and publishing [3].

The OECD (2023) stated that AI models may be able to provide many opportunities via delivering tasks in human natural language; however, their use requires quality

control and standards. AI language models may facilitate and enhance the production and distribution of misinformation and manipulated language-based content that may be impossible to distinguish from factual information. This may also threaten the public trust in institutions [4]. Recently, UNESCO published a quick start guide which provides information on how ChatGPT works and how it can be safely used by higher education [5]. Some possible uses of ChatGPT in higher education were mentioned, such as research design, data collection, data analysis, and writing up. The main suggestions for adapting ChatGPT in higher education institutes include "using ChatGPT with care" and "building capacity to understand and manage ChatGPT". It is highlighted that it is possible to use it safely if one has the expertise to validate the output and is willing to take the responsibility for missed inaccuracies, or when the accuracy of the output is not important [5].

In the scope of environmental research, Rillig et al. (2023) discussed the risks and benefits of LLM for the environment. They considered both negative and positive sides of LLMs on direct environmental impacts (e.g., energy consumption), indirect environmental impacts (e.g., availability of information), and impacts on environmental research (e.g., reduced language barriers). They emphasized the importance of starting the discussion early to prevent possible harm [6]. Zhu et al. (2023) focused on ChatGPT and environmental research, and evaluated how ChatGPT responded to diverse questions from different areas of environmental research. They indicated the benefits as improvements in writing, information retrieval, coding help, and syntax explanation, whilst they emphasized the problems as lack of updated knowledge and fabricated information, lack of accountability in decision making, and opportunity costs of relying on ChatGPT [7].

Conversational AI tools can also be used for content creation. Through being a public concern, topics related to environmental pollution are widely found in newspapers, online web-sites, magazines, and blogs which have a broad public reach. Thus, we find it extremely important to assess the possibility of integrating AI tools in environmental-related content writing. Rillig et al. (2023) also stated that the major concern is that "some groups may exploit the ability of LLMs to generate text with unprecedented efficiency, thus offering misinformation under the guise of artificial intelligence" to the public [6].

To our knowledge, the main focus of research into conversational AI tools is currently on ChatGPT, is limited to content in English, and lacks the assessment of diverse specific topics in an environmental context. The aim of our work was therefore to (i) find out whether the answers provided by conversational AI tools are satisfactory for various environmental topics (microplastics, tire wear particles, advanced materials, and engineered nanomaterials), (ii) assess the differences between different conversational AI tools, and (iii) check the effect of different languages using native speakers. In addition, our study may enable tracking the development of conversational AI tools on environmental topics when, and "if", similar publications become available in the future.

2. Methodology

In the context of environmental research, we focused on the following areas where the authors are experts: microplastics and tire wear particles, advanced materials (AdMa), and engineered nanomaterials (ENM). As a first step, we opened a pool of questions from the authors and requested input on selected topics that may be relevant to the general public or those interested in the subject. The questions were then categorized as "general", "specific", and "expert-level" depending on the scope of the question and the knowledge required for the answer. This categorization was approximate, as it depends on interpretation. For each topic, a total of nine questions, representing three questions from each level, were used. The questions can be found in Figure 1. The questions were then asked of ChatGPT from a new account between 8 April and 6 June (Versions March 23–June 14) from Switzerland, and the answers were recorded. The word limit of the answers was set to 200 words. We also checked the answers via changing the word limit to 400 to assure that the content was not limited by the word limit.

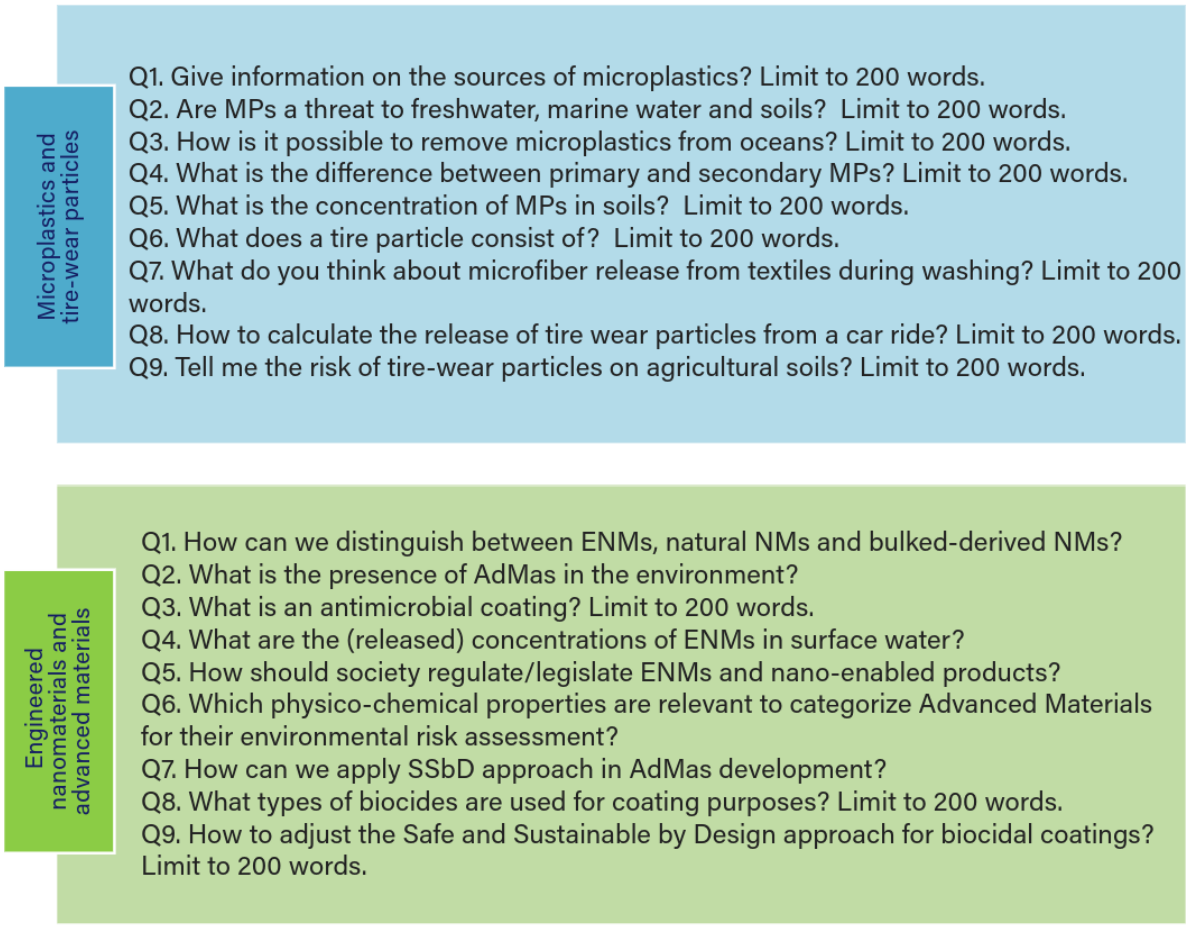

Figure 1. Questions asked. Level of the questions: general: Q1, Q2, Q3; specific: Q4, Q5, Q6; expert: Q7, Q8, Q9. MPs: microplastics, ENMs: engineered nanomaterials, AdMas: advanced materials, SSbD: safe and sustainable by design.

To test the effect of different AI tools and different languages, three randomly selected questions from the topic of microplastics were asked through using new accounts. Chinese, German, Turkish, Spanish, and Korean were tested by native speakers and then compared with English answers. For different AI tools, we tested Microsoft Bing Chat and Google Bard. Answers for Bing and Bard were generated on 11 April from Switzerland, and on 13 May from USA, respectively—because Bard was not yet released at that time in Europe—. The same procedure was applied and three randomly selected questions from the topic of microplastics were asked, and the answers were compared to the answers of ChatGPT. The questions were asked twice in each language and of each tool to prevent possible misinformation due to the answer generated. To select the questions randomly, each question was given a number, and three different randomized number generations were created by using https://www.random.org/ (accessed on 11 April 2023). The selected questions can be found in Tables S1 and S2, for different languages and tools, respectively.

3. Results and Discussion

3.1. Content Quality

All answers can be found in the SI Section S1. No obvious difference was observed between the replies to the questions for different levels in terms of content or the quality of the answer given. Overall, the responses were largely satisfactory both for microplastics, engineered nanomaterials, and advanced materials, although a few minor gaps and debatable points were identified in some instances.

3.1.1. Microplastics

When asked about the sources of microplastics, ChatGPT was able to provide primary and secondary sources with some examples and even mentioned microfiber release from the textiles. While an upper size limit was specified, no corresponding lower limit was established. This omission may result in the inadvertent consideration of nanoplastics (plastic particles smaller than 1 µm) as microplastics. When it comes to the threat of microplastics on different ecosystems, the main concepts were pointed out clearly. However, for plants, the effect was given as "reducing crop yields", whilst an increase in crop yields may also be observed [8,9]. However, this knowledge may be considered as expert knowledge. As some of the questions were asked two times, it was observed that some new aspects were presented in the second answer. For instance, while no information was given on the effects of MPs on soil organisms in Q5, it was covered in the second run. This may be due to the "randomness of the answer generated" where the answers produced exhibit a degree of unpredictability in terms of context. Zhu et al. (2023) stated that "ChatGPT provides a single response that lacks diversity" [7]. Therefore, it may be crucial to ask the same question several times and assess the answers accordingly to obtain a more content-rich text.

The quality of drinking water was also mentioned (Q2), however, to our knowledge there is no indicator to test this; however, undoubtedly, drinking water contaminated with microplastics cannot be considered "high-quality". In the same answer, introducing chemicals and pathogens was also included. It is already known that the additives of microplastics may leach with time into the ecosystems [10,11], and pathogens may accumulate on microplastics as well [12] (Gkoutselis et al., 2021).

While the distinction between primary and secondary microplastics was clearly explained, the statement that "Primary microplastics tend to be smaller in size than secondary microplastics"may be debatable. This is because the process of microplastic fragmentation can also produce nanoplastics. In the second run, it was seen that "the smaller size of secondary microplastics also makes them more easily ingested by a wider range of organisms", which contradicted the previous answer. It also stated that due to the distribution and persistence of secondary microplastics, they may pose higher risks. Based on our knowledge, there is no study yet to confirm these mentioned points.

A very wide range was given for the concentration of microplastics in soils: "a few particles—hundred particles per kilogram", which can be considered as partially true. When asked the same question in the second run, the concentration was reported as "a few hundred particles per kilogram to several thousand particles per kilogram for agricultural soils". There have been many studies that reported microplastic concentrations within these ranges. Some examples can be found in [13–16]. Previously, we reported the median value of microplastic concentration in soils as 930 particles/kg [17]. However, there are also samples with no microplastic concentration detected [18,19], as well as microplastic concentrations of hundred thousands particles per kg of soil [20]. The same answer (A5) also covered the effect of different land uses. As per our findings from [17], it is accurate to state that urban areas typically exhibit the highest concentrations of microplastics in soil. The most significant issue pertains to the lack of references provided to support the arguments presented. For instance, two examples were given for urban soils in China (as 37–440 particles/kg soil), and agricultural soils in Europe (as 1–10 particles/kg soil). However, we could not confirm these exact references in the literature (the literature research was only performed in English). Chai et al. (2020) reported no microplastics [18], whilst [21,22] reported 449 and 95 part/kg for urban soils in China, respectively. The results of [23] on agricultural soils in Europe showed the range to be between 0 and 8.8 part/kg. Nevertheless, there are also other studies that presented much higher microplastic concentrations in urban soils in China [21], and agricultural soils in Europe such as [24–26].

It is imperative to verify the references of any numeric results provided, while bearing in mind that they may not necessarily be representative, but rather intended as illustrative examples which need to be checked further. Zhu et al. (2023) also stated that they found

some of the responses as informative; however, they may also include incorrect information [7]. While we specifically did not receive any clearly wrong answer, we found some statements debatable. For instance, in A5 "While the concentration of microplastics in soils may appear relatively low compared to other environments—" (A5) is open to debate. Our exposure results showed that the concentration of microplastics is higher in soils than in oceans [17]; however, much more data are needed to be able to confirm such a statement. It should be noted that the analytical techniques (e.g., filter pore size, digestion of the sample) may also have an effect on the final numeric results when determining the microplastic concentration in soil samples.

The answers for the removal of microplastics from oceans include skimming, usage of sorbent materials, electrostatic attraction, biodegradation as well as usage of ultraviolet light (UV). Specifically, for UV light, it is stated that microplastics can be broken down using UV light which makes them easier to remove. Delre et al. (2023) showed that UV light can degrade floating plastics under simulated marine conditions [27]. Although ChatGPT did not provide further mechanisms that make them easier to remove, it is known that smaller particles may settle more slowly but could heteroagglomerate, facilitating settling as larger agglomerates.

We found it interesting that the answer on the release of microfibers from textiles during washing included "using liquid laundry detergents instead of powder detergents" as one of the solutions to reduce the release of microfibers, since there are more well-known mitigating solutions available and this particular solution was presented with a comparative point. Although some studies support that liquid detergents may perform better [28,29], some studies found no significant difference between liquid and powder detergents [30,31]. Therefore, ChatGPT has chosen only one side and presented it as an absolute fact. Agathokleous et al. (2023) stated that ChatGPT may tend to assign greater significance to the most abundant information [32]. So, this could potentially be one of the reasons behind this. However, it should be noted that since this question was asked only once, there may be a possibility that it provides other solutions or does not even mention this point when asked multiple times.

When the word limit was set to 400 instead of 200, the content was similar on tested questions (SI; Section S4), but additional information was provided. For instance, size and type of microplastics with examples were provided, and mobility was mentioned in A5 in the longer version. The same was observed for question 4 and 8. The release pathways of microplastics into the environment, their relative abundance, the environmental impact of primary and secondary microplastics, and step-by-step approach, together with additional methods were mentioned for question 4, and 8, respectively. The answers were not checked further to verify the content provided. Depending on what information is being looked for, the word count may be taken into account.

3.1.2. Engineered Nanomaterials and Advanced Materials

To the question, how we can distinguish between ENM, natural nanomaterials, and bulk-derived nanomaterials, ChatGPT gave a general definition of each type of nanomaterial mentioned in the question, which relates to the ones found in the literature [33–35]. Furthermore, it highlighted that it is challenging to distinguish them. For example, when coated ENM are released to the environment from nano-enabled products, these surface functionalizations can be lost and there could be no evident distinction with a natural NM with similar phys-chem characteristics [36]. The only point which is debatable is when ChatGPT mentions carbon nanotubes (CNTs) in volcanic ash because so far only halloysite or imogolite nanotubes (composed of inorganic minerals) have been identified in volcanic soils [37], not CNTs. It would be helpful if ChatGPT would provide the references because of the transparency and reliability of its answers, because then one could verify the source of information. Even though it is true that analytical characterization techniques are used to identify the presence of NMs in a sample and to describe their phys-chem properties, so far only ICP-MS-based techniques have shown enough sensitivity to analyze inorganic

ENM in complex environmental samples [38]. In the case of organic ENM, equally sensitive methods are lacking [38], which may make them "virtually indistinguishable from incidental or natural NMs" [35]. However, the combination of multiple advanced analytical instruments and methods with proper and updated regional monitoring data regarding market products and biogeochemical background data could be useful to better understand and distinguish these types of NMs in environmental matrices [38].

Regarding the emissions of ENM into the environment (Q4), particularly surface water as an example, ChatGPT did not mention the amount. There are several modeling studies which report ENM concentrations in surface water but there is a very large spread of the reported values [35]. As a language processing model, ChatGPT generates a reasonable text about the distribution of ENM in surface water to answer the questions instead of a precise and strict scientific discussion. To think of the text from a scientific perspective, it only points out that studies have been implemented to investigate the existence of ENM in surface waters. It did state the challenges and difficulties regarding measuring the concentration and also mentioned the further need for monitoring and research initiatives to improve our understanding of the potential risks. In the scientific world, we still need to implement certain research to have a clear answer, such as environmental fate modeling [39], transport modeling, or exposure modeling [40–42].

Furthermore, when asking ChatGPT to inform about the regulatory context of ENM (Q5), the AI tool gave an accurate response. It covered several points from an international risk governance point of view that have been discussed for many years, such as risk analysis, risk management, risk communication (and transparency), international collaboration, and using flexible and adaptable approaches integrating several stakeholders [43,44]. Moreover, it added the importance of responsible and innovative research models while developing safe and ethical technologies [45,46]. Even the term "sustainable development" appeared, which has been integrated in the latest work of some European projects focusing on the implementation of decision-making tools in a risk governance context [47]. Nowadays, there is no international regulation of nanomaterial-based products and nanotechnology [48], probably due to a conflict of perspectives in the regulatory arena among international stakeholders and decision-makers [49]. Nevertheless, some countries have applied similar points of this framework mentioned in the answer to regulate ENMs and nano-enabled products, such as in Europe, the US, and Japan [50,51].

In the topic of advanced materials (AdMas), ChatGPT acknowledged the benefits of AdMas in revolutionizing various industries. In the context of AdMas, a clear and universally accepted definition is yet to be established. Currently, these materials are loosely defined as those that exhibit new or improved properties. However, there is a recognized need for a cohesive and comprehensive definition system [52,53]. ChatGPT acknowledged the benefits of AdMas in various industries first before it answered in regard to the presence of AdMas in the environment (answer to Q2). It also stated the importance of investigating the distribution of AdMas in the environment and the potential risk they can cause to the environment and human life related to different AdMas application processes. Regarding the risks of AdMas, scientists are starting to work on this issue but there is so far not much research focusing on the complete picture of AdMas. Existing studies are limited to specific materials, and ENMs still take up a large portion of the studies. ChatGPT also mentioned the need for practices to address these challenges, such as eco-friendly manufacturing, recycling, and comprehensive research on environmental impacts. It emphasized the importance of adopting sustainable practices and conducting research to mitigate the environmental challenges of AdMas, which is compatible with the safe and sustainable by design (SSbD) concept [54].

ChatGPT provided information on the physico-chemical properties that are relevant for categorizing AdMas for environmental risk assessment (answer to Q6). It suggested the inclusion of toxicity, persistence, bioaccumulation, mobility, solubility, reactivity, and particle size. It is a comprehensive answer for a specific question.

Safe and sustainable by design (SSbD) aims to minimize hazard, source resources ethically, and operate under environmental and social principles. While ChatGPT provided correct responses to Q7 on a per-item basis, it failed to provide a high-level answer that integrated all of the items that provide insight. Also, it missed one of the important SSbD approaches in development which involves searching for alternative materials with the same purpose but lower toxicity or environmental impact to mitigate potential environmental risks. Sustainable sourcing and disposal of materials and products are critical for environmental sustainability. This lack of insights may be due to the fact that the final JRC report on the SSbD framework was published only in 2022 [55] and ChatGPT has limited knowledge and information after 2021 [56]. As our questions only covered the definition and meaning of SSbD, we cannot draw any conclusions how AI tools may be used in the future to identify alternative, more safer materials. The same applies to the answer to Question 9, where we asked how to adjust the SSbD concept for biocidal coatings. Overall, it covered the SSbD concept quite well, replacing the word "material" for "biocidal coatings", providing a generic answer. This answer, as expected, lacks any special approach that can be followed for biocides.

The definition and application areas of nanocoatings (Q8) were well covered, providing examples of target organisms, use cases, and active ingredients for antimicrobial coatings. Even though nanocoatings in general were asked about, the answer was focused on antimicrobial coatings. Both oxidizing and non-oxidizing impacts where the metabolic processes of microorganisms were inhibited were mentioned in the first and the second answers, respectively. Additionally, although not asked specifically, it mentioned the necessity of regulatory monitoring and maintenance as well. As previously mentioned, ChatGPT provided additional aspects on the topic asked, which could be considered as one of the advantageous aspects of the tool. When types of biocides used for coating purposes were asked (Q17), silver, zinc, copper, quaternary ammonium compounds, and organic biocides were provided, mentioning the importance of the choice of the biocide depending on the target organism and application scenario. However, titanium oxide which is one of the commonly used biocides [57], was not mentioned.

3.2. Differences Observed When Using Different Conversational AI Tools

The content of the responses derived from different conversational tools were similar with some differences in content, numeric values, and the length of the text.

Bing provided the source of the reference, which we see as a significant advantage, whilst the length of the text was comparably shorter, giving only the specific answer to the question asked. For instance, when the concentration of microplastics was asked of Bing, it provided numeric values, similar to ChatGPT. Up to 13,000 items/kg soil was reported, which may not be considered as representative but as an example. However, since it provided the sources of the information, it is much easier to track and see the content of the study which may enable further discussion. When the accuracy of the answers was monitored using the sources, it was observed that the given values were correct. However, it was discovered that the cited reference was not the original study but a secondary source that utilized and cited the original study. For instance, it was stated that the amount of microplastics entering the soil through the application of agricultural sludge in North America ranges from 63,000 to 430,000 t per year, and is approximately 44,000 to 300,000 t in Europe, which was cited as [58], whereas it actually belongs to [59]. The same observation applies to the microplastic concentration in Australia. The tool cited the reference as [60], whereas the main information originates from [61]. For the tire wear particles, the information originated from [62], but the reference was given as [63]. The references were not always from academic sources but also from web-sites such as "nationalgeographic.com" or "differencebetween.net". Another important aspect is the inclusion of more up-to-date information in Bing, which provided references from 2022 and 2023 as well, whereas the training data of ChatGPT only extend to 2021. The numeric values generated were not the same when being asked the second time in Bing as well, similar to

ChatGPT. For instance, the microplastic concentration in the given answer in Australian soils was 67,500 mg/kg, and 2400 mg/kg for the first and second questions, respectively. However, still, it is possible to learn further since the references were provided. It is also advisable for Bing to ask the same questions several times, since it produces different information and once it stated that "I am not sure if this is what you are looking for. Could you please provide more details about your question?", even though a satisfactory answer was provided for the same question when asked for the first time.

Bard provided longer answers, similar to ChatGPT, but generated "a more similar answer" when asked for the second time compared to ChatGPT. Still, differences between answers were present. For instance, the microplastic concentrations were reported as "up to tens of thousands of particles per kilogram" for the first answer, and as "generally in the range of 100 to 10,000 particles per kilogram of dry soil. Some studies have reported even higher concentrations, up to 100,000 particles per kilogram" for the second answer. Different values generated via different tools can be seen in Figure 2, and Table S3. An overview of different tools and languages is provided in Figure 3. A listing method was observed in Bard, which may be advantageous but at the same time may result in misunderstandings due to the usage of a single word. For instance, even though primary and secondary microplastics were well defined in Bard, "agriculture", "filtration", and "medical devices" (SI; Section S2.2 Q4), were given as examples of primary microplastics, which is not what we would usually think (e.g., pellets, microbeads in personal care products or paints). Zhu et al. (2023) stated that different formats as well as answers for different audiences can also be obtained in ChatGPT [7]. An exact formula (for Q8) was also provided in Bard, which may be helpful to understand one of the approaches used, or make calculations based on the data possessed. The formula was provided for the tire wear particles as can be seen from SI, Section S2.2. The answers given were the same both in the first and second run of questions, which we did not expect for ChatGPT. An additional sign was added "use code with (where a link (https://bard.google.com/faq?hl=en#coding) was provided to the FAQ page of Bard). However, it provided an answer which we cannot relate to any paper that normally would be cited in the field of tire wear particle emissions. The equation provided might theoretically work from a perspective of friction but does not take the differences of tires into account. Based on this equation, different studies should obtain very similar results for tire wear particle emissions; however, [63] did clearly show the opposite. Therefore, we also advise verifying the information generated by Bard with an expert, since it stated the primary microplastics are the major source of microplastic pollution, which is clearly not correct.

Overall, the answers were similar to each other but we found that the possibility of generating an answer with different aspects may be higher in ChatGPT, followed by Bing, and then Bard. ChatGPT provided answers covering also different aspects, while Bing provided shorter and more concentrated answers, and Bard provided nearly the same or very close answers when being asked for the second time. For the numeric values, since the same tool may also generate different values for the same question, we currently cannot conclude if the numeric values provided by different tools are different from each other. Overall, utilizing AI tools for the evaluated topics may provide valuable aspects, even though further validation and input—depending on the focus of the content—is required. Agathokleous et al. (2023) also assessed ChatGPT with a special focus on plant sciences. They stated that ChatGPT provided many common aspects with scientists, yet it was incapable of capturing all facets. Nevertheless, it is indicated that humans can derive advantages from large language models via obtaining initial material which serves as a foundation for further development [32].

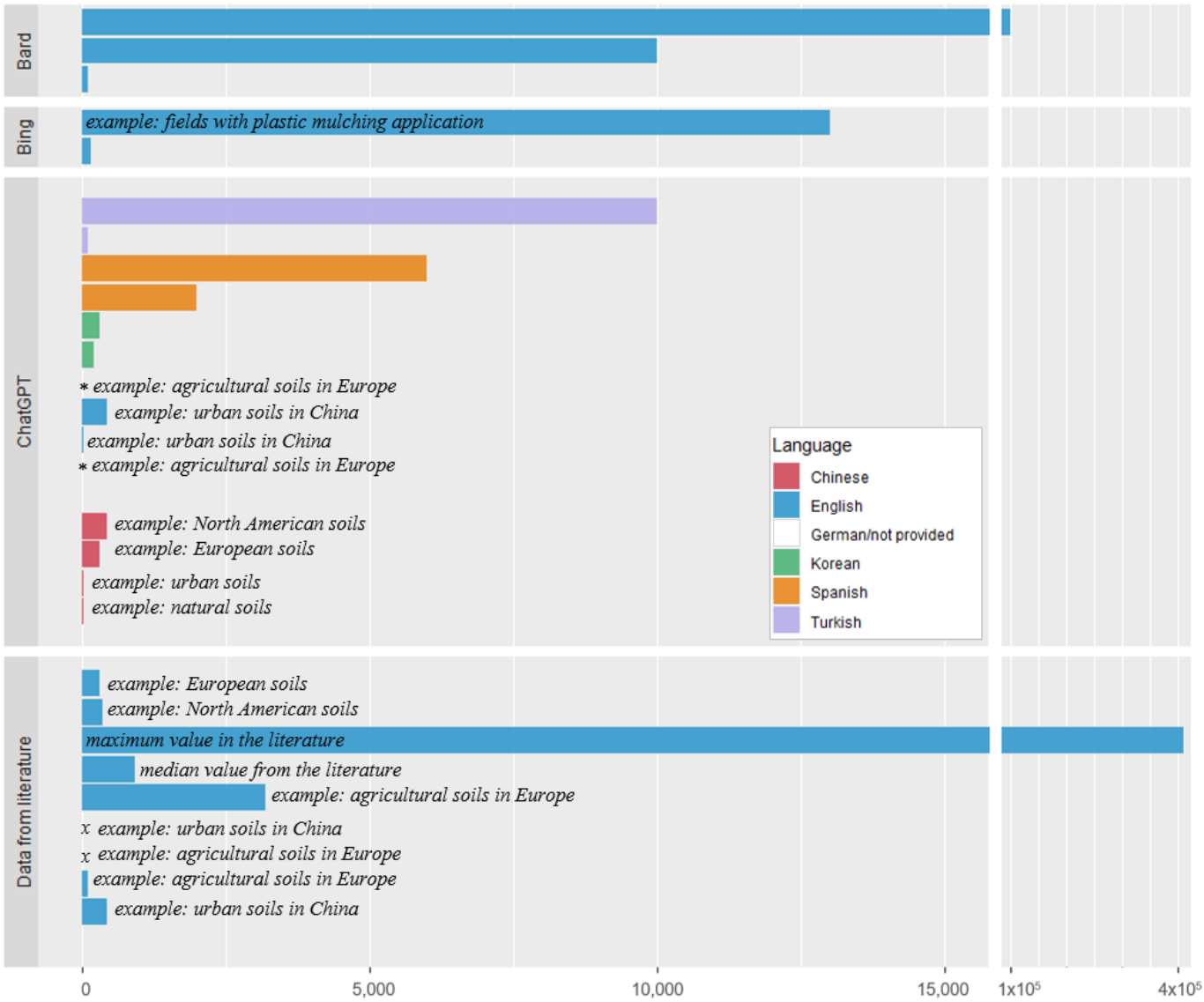

Figure 2. Numerical values reported as particle/kg by different tools and languages and data from literature for microplastic concentration in soils. Concentrations = 0 part/kg are shown with "x". Concentrations not visible on the graph are shown with "*", representing 1 and 10 part/kg. Further information about the data was provided as text, if available. No numeric value was reported in German.

For the abbreviations, ChatGPT misinterpreted the abbreviations two times. "MP", which was used as an abbreviation for "microplastics", was interpreted as "Members of Parliament" (SI—Section S2.3—Q4 2nd run), and SSbD as "Sustainable-by-Design" (SbD) instead of "Safe and Sustainable-by-Design" (SI—Section S1.2—Q7). We did not observe any misinterpretation of the abbreviations for other tools; however, the number of questions asked of the other tools was limited compared to ChatGPT. For instance, the SSbD questions were never asked of Bard or Bing.

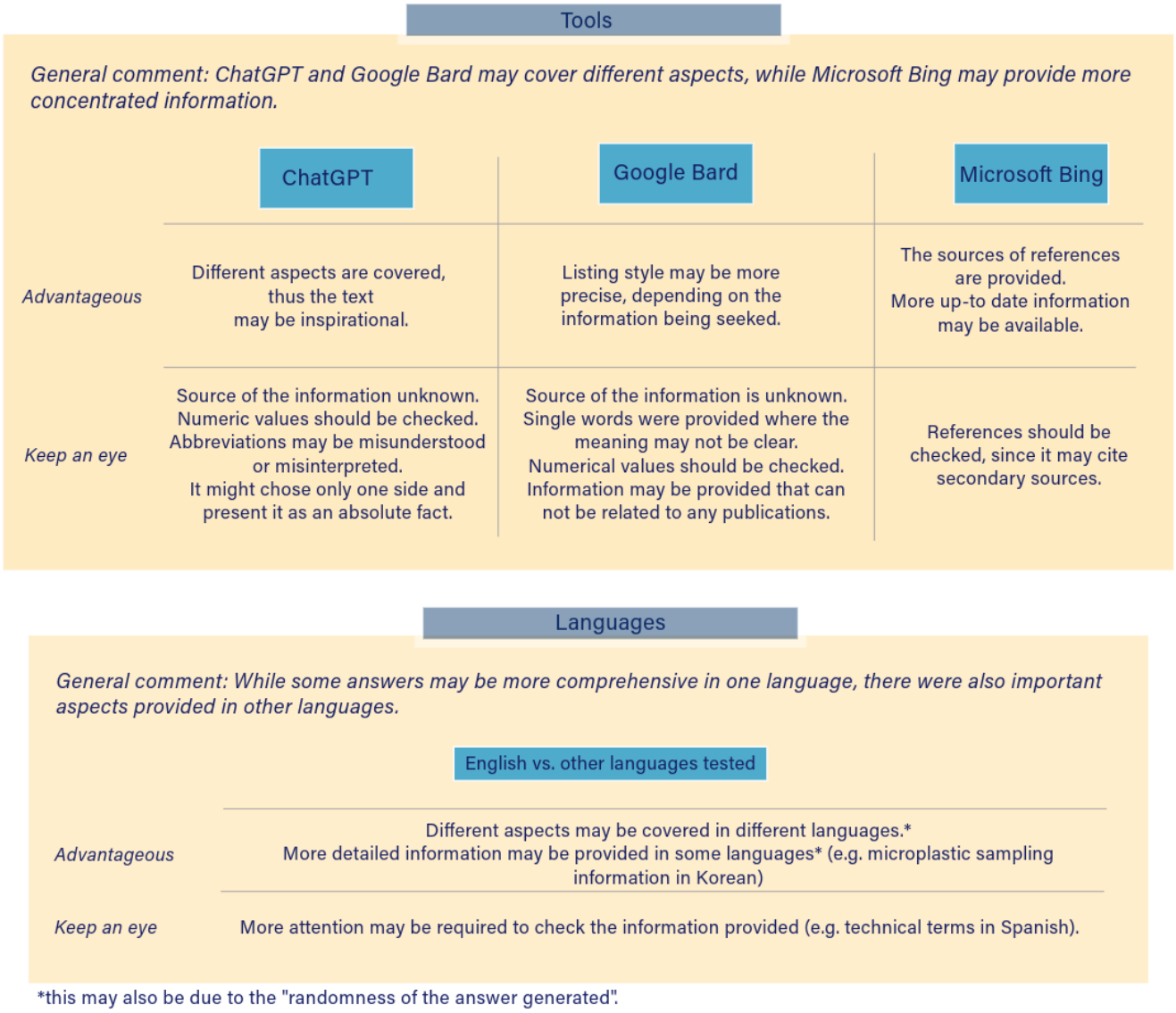

Figure 3. An overview of different tools and languages.

3.3. Differences Observed When Using Different Languages

The overall content of the answers in different languages was comparable; however, certain variations emerged when the questions were asked in different languages. These disparities encompassed the scope of the topics addressed, reported numerical values, omission of important details, and the potential use of terminology that could lead to confusion. In general, the English answers seemed to be more comprehensive. However, it was noticed that certain significant points, which were not mentioned in English, may appear in other languages. An example from the aspects covered was that in Korean, it was reported that the microplastic concentration may depend on the extraction and analytical method, which we see as an important point to consider when determining the concentration of microplastics, since the microplastic concentration found may directly depend on several factors such as filter pore size. Sample collection together with detection was mentioned in Chinese as well. Some suggestions (e.g., practicing sustainable farming) to decrease the concentration of microplastics in agricultural soils were provided in Turkish answers, whereas the usage of new technologies and agricultural practices (e.g., low pressure tires) to reduce the concentration of tire wear particles was suggested in Spanish.

In addition, a circular economy concept that promotes tire recycling was emphasized in Spanish, which was not observed in other languages.

Depending on the language asked, ChatGPT responded with different exposure concentrations for soils. The exposure was reported differently both in terms of general ranges and specific numeric values. For instance, the exposure was reported as tens to hundreds of particles per kg of soil in Chinese, and from less than 1 to over 10,000 particles per kg of soil in Korean. However, different ranges were also observed in English answers, as previously discussed. English answers show similarity to German answers, as both reported the exposure as ranging from a few hundred to several thousands of particles per kilogram of soil. The numeric values also exhibited differences among the different languages as shown in Figure 2, and Table S3. The exposure was reported as 100–10,000 part/kg in Turkish, and 2000–6000 part/kg in Spanish, which is different than that reported in English (1–440 particles per kilogram; note that these values were provided as examples). The average concentration of microplastics was reported to be 200–300 particles per kilogram in Korean. Chinese answers include examples from European soils, North American soils, urban soils, and natural soils, representing 300, 440, 38, and 20 part/kg, respectively. [19] as well as [64] reported slightly close microplastic concentrations at 301 and 358 part/kg for European and North American soils, respectively. However, it should be noted that lower microplastic concentrations were found for North American soils [64], and both lower and higher microplastics concentrations for European soils [19] in the same research papers. For the urban and natural soils, we previously reported the microplastic concentrations in urban soils and natural soils may vary between 0 and 410,000, and 0 and 14,350 part/kg, respectively [17]. As stated earlier, the numeric values cannot be considered representative but as an example that require validation. Also, it should be noted that these values were obtained in one of the answers in each language by asking the questions two times. The values may differ if asked again due to the "randomness of the generated answer". The accuracy of the numbers provided was only checked from the publications in English, while no additional research was conducted for publications in different languages.

On the other hand, there may be confusion due to the terminology in different languages. For instance, ChatGPT stated "diferentes medios ambientales" which could be a literal translation from English to Spanish of "different environments", which could be incorrect in Spanish because it might have wanted to refer to different environmental compartments (this case to soil) or environmentally diverse conditions in an environmental compartment, and the word is mainly used in singular (el medio ambiente, el ambiente or less common el medioambiente). Additionally, ChatGPT mentioned a second name for tire particles as "polvo de neumático", which led us to make a small research on the definition. This term has been used in research in Spanish (mainly due to its possible application to asphalt in order to add a particular property to this material), which is defined as the powder "coming from an industrial process for shredding tires out of use" [65]. A particle in polvo de neumático is clearly something very different to a tire wear particle produced by abrasion on roads. In Turkish, the microplastic concentration was defined as it depends on where "they are buried in the soil", which is not very clear and may rise some confusion or misinformation.

It is also worth noting that some significant points were missing in certain languages. For instance, in German, the transport towards air and soil was highlighted, while the water path was not mentioned for the tire wear particles. The effect of tire wear particles on aquatic life was reported in Korean, while other ecosystems were not mentioned. This phenomenon does not necessarily depend on the impact of language alone, as other content can be generated with the same question as well. The factors that may affect the composition of tire wear particles were not covered in languages except English and Korean, which we see as important aspects to cover. There was another example in German where the additives were not mentioned, although the risks of tire wear particles on agricultural soils were covered nearly the same way between German and English, stating the change in soil properties, nutrient balances, and the impact of heavy metals. It may be possible that these

differences may not be due to the effect of language but rather may reflect the generation of diverse answers covering different aspects, as previously discussed.

On the other hand, the probability may be higher for having similar content between German and English. Lai et al. (2023) assessed the effect of different languages for different tasks including question answering, where they provided an information paragraph followed by questions. They reported that English answers were significantly better than the other assessed languages. Also, the performance score of German, together with Spanish, was higher than other assessed languages for question answering [66]. However, since they used an online translator, and the assessed languages were not exactly the same, there may be uncertainties resulting from the translation itself; thus, our results may not be comparable.

On the other hand, depending on the content of the question, there may be a possibility of receiving a more precise answer in some languages for a specific question. For instance, the answer to the risk of microplastics in agricultural soils in Chinese was very structured and more precise compared to English; however, this did not apply to all of the Chinese answers. However, it should again be noted that this may also be due to the "randomness of the answer generated". This can be further evaluated by asking the same questions many times considering other factors that may affect the response generated. Some languages may require more attention and research depending on the expertise level. For example, the reported accumulation of microplastics in topsoils as presented in the Spanish version, particularly in close proximity to plants and roots, requires additional verification. One surprising answer was receiving an identical response regarding tire wear particles in both Turkish and English. This occurrence may be attributed to the use of the same account for posing questions in both languages, which warrants further investigation. It is important to note that this was observed only for a single question.

Differences were also observed for the same questions when asked in the second run in other languages as well, similar to English as discussed previously. For instance, in Spanish, the factors that affected microplastic concentrations were modified in the second answer. Thus, it is not possible to conclude the exact differences between the languages. For German, a second run produced, generally speaking, very similar results. Wording and content was rearranged but not changed a lot. The answer only changed slightly for the question about "concentration". Here, concentrations were provided in two different units. Once in particle numbers per mass soil and once in mass of plastics per mass of soil. However, both answers were more general, providing ranges instead of concrete numbers.

We may suggest the use of different languages, if possible, as well as asking the same question several times to cross-check, while preferring to avoid the usage of numeric values unless the source was tracked.

4. Conclusions

In general, good coverage was provided in terms of content in ChatGPT, Bard, and Bing, as well as with the languages assessed by ChatGPT. Usage of conversational AI tools may provide many advantages, while some crucial aspects need to be considered. It is highly advisable to ask the same questions several times, particularly of ChatGPT to increase the probability of covering all aspects. A text that is richer in content can potentially be achieved by employing various techniques such as repeating the questions, increasing the word count, or, to a certain extent, posing the questions in different languages, but with a lower probability. The numeric values cannot be considered representative but as an example. However, it is uncertain whether the numeric values provided as examples are representative of the wider range of microplastic concentrations found in the literature, which exhibit significant variability and can span a wide range. It is thus advisable to be cautious before using numeric values. Bing is very useful in this sense since it provides the references. However, we also advise checking those references. The answers of ChatGPT were longer, which may be advantageous for those seeking to expand their knowledge but are uncertain where to begin or what to search for.

Overall, we think that the answers represent good-quality content covering different aspects. When harmonized with minor research work from an expert, the outputs may represent high-quality text. Without such a validation of the information, non-experts may expose the audience to incomplete or partially incorrect information, introducing possible bias on a topic. Even at an expert level, results from LLM may provide different aspects to be considered, and may help to produce a comprehensive outline of scientific content suitable for all levels. In addition, institutions as well as governing bodies may also benefit from AI tools to engage with the public.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su151914453/s1. Questions asked and answers obtained.

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