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ENVIRONMENTAL BEHAVIOUR FOR THE PREVENTION OF RISKS CAUSED BY EMERGING POLLUTANTS: THE CASE OF MICROPLASTICS

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The road to hell is paved with good intentions.

European proverb

This we know: the earth does not belong to man; man belongs to the earth. All things are connected like the blood that unites us all. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself.

Chief Seathl, Puget Sound

Lo que nos inspira no son los premios, sino los principios. Lo que nos alienta es saber que aquí no hay otro planeta de repuesto. Solo hay uno.

Berta Cáceres, Honduras

Esta Tesis está dedicada a Pablo, Miguel, María y Aida, y a la peque que está a punto de llegar.

Acknowledgments / Agradecimientos

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Seguramente la experiencia es un grado, pero no para dedicatorias y agradecimientos que son cada vez más complicados porque se multiplican las personas a quienes dar las gracias, incluyendo a mi madre Gelos, mi madrastra Edita y mi querida Gemina que nos dejaron demasiado pronto. Por no abrumar seré genérica; ya sabéis quiénes sois. Así pues: Familia, amig@s, compañer@s de trabajo, doctorand@s … sin remedio, me temo que ya voy a ser doctora de forma irreversible. Va por vosotr@s.

Mi primera Tesis se la dediqué a mis hijos Pablo y Miguel por no habérsela comido (literalmente, pues eran bebés intrépidos y voraces), y en esta segunda añado con orgullo a mis hijas María y Aida. Pedazo de personas las cuatro. Animan, apoyan y están ahí, físicamente y al otro lado de la pantalla en la pandemia y en la emigración.

Aunque esta vez “hacer la tesis” no robó demasiado tiempo –espero- a mi sufrida descendencia, sí se lo robó a mi padre Conrado, quien con su novena década a cuestas aún tiene el humor de llamarme pequeñina. También a Eduardo, mi compañero de vida, por tantos fines de semana pegada al ordenador. ¡¡¡¡Gracias por todo!!!!

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CHAPTER 1

GENERAL INTRODUCTION

1.1. The microplastics crisis. Origin and risks.

In the current scenario of global change, emerging pollutants are one of the major threats for their still impredictable effect in humans and ecosystems on the long term. The list of those new pollutants is impressive accounting from antibiotics to hormones to microplastics. These small pieces and fibers of plastic (Figure 1.1), often invisible to the naked eye and ubiquous, are the core of this Thesis.

Figure 1.1. Photograph of microplastics collected from a beach.

The ubiquity of microplastics is a paradigm today. Actually, there are two elements common to all the ecosystems where life occurs: water and plastic. Small plastic particles have been found from the fragile atmosphere of the highest mountains (Bergmann et al., 2019; Zhang et al., 2020a) to the deepest abyssal trenches (Abel et al., 2021). The dimension of this phenomenon is so big that the term *microplastics crisis* was coined to designate such a large-scale invisible pollution three years ago (Shen et al., 2020).

The origin of plastic is anthropogenic as it is that of the microplastics. Massive production of plastics from crude oil started in the 50s of the 20th century for the many advantages of this material: high strength-to-weight ratio, high moldability, impermeability to liquids, resistance to physical and chemical degradation, and low cost. For their resistance to degradation, they can persist as waste in the environment for decades or even centuries. As a recent example of its utility and drawbacks, in the COVID-19 pandemics plastic was essential for the production of hygienic masks and hospital wear; though plastics use fell overall by 2.2% from 2019 levels, plastics waste increased due to the use of protective personal equipment and single-use plastics (OECD, 2022).

The predicted growth in plastic waste reaches a figure of 53 million Tm of annual emissions by 2030 (Borrelle et al., 2020). The problem appears when plastic

waste is not effectively managed. Global annual plastic waste has more than doubled, from 156 Mt in 2000 to 353 Mt in 2019, the last year with data not affected by COVID-19 pandemics. Almost two-thirds of all plastic waste comes from applications with lifespans of less than five years: packaging (40%), consumer products (12%) and textiles (11%). After taking into account losses during recycling, only 9% of plastic waste was ultimately recycled, while 19% was incinerated and almost 50% went to sanitary landfills. The remaining 22% was disposed of in uncontrolled dumpsites, burned in open pits or leaked into the environment (OECD, 2022). After plastic objects enter in the ecosystems, they break by the action of wind, running water or waves, also due to UV radiation. The products of such breakage are progressively smaller plastic fragments, which are called microplastics when they are smaller than 5 mm. When they are smaller than 1 micron, they are called nanoplastics (Mariano et al., 2021). For simplification we will refer generically to microplastics, knowing that the same reasoning to control them can be applied to nanoplastics.

In addition to the microplastics originated from large plastics breakage, there are microparticles produced directly of a size smaller than 5mm, and particulate emissions released from industrial production –plastic dust (Laskar & Kumar, 2019). Microplastics are manufactured for addition in cleansers as abrasive; for personal care products like whitening toothpaste and exfoliants; in form of microbeads to carry medicaments and active principles in medicine and cosmetics; in clinical assays; in roads and building paintings; as decorative glitter; and many other uses (Loganathan & Kizhakedathi, 2023). Microplastics produced directly of that size are called primary microplastics, in opposition to those obtained from fragmentation of larger plastics that are called secondary microplastics (Yuan et al., 2022).

Although there are different technical solutions for the degradation or conversion of microplastics into less problematic substances (like biorecycling, photocatalytic conversion, hydrocraking; Tian et al., 2023), size does matter for the real application of such techniques to solve currently widespread pollution. Being so small, a significant part of microplastics can escape the water treatment plants (Kwon et al., 2022). The same reason makes it too difficult to remove secondary microplastics from the environment. While large plastics can be seen, picked, or trapped, and removed from the environment, microplastics are simply invisible. Although different methods have been assayed to date, like filtration, coagulation or floculation, none has been proven totally efficient (Ahmed et al., 2022). Some assays are looking for bioremediation using for example animals that are able to remove microplastics from ocean waters (Corona et al., 2020), but their application at a large scale is yet to be explored.

Microplastics as emerging contaminants are of big concern for scientists because they are already threatening ecosystem and species functioning (Sharma et al., 2023). The marine realm has been more studied because the ocean acts as a sink for plastics and microplastics, that are transported by runoffs from landfills to the rivers and by rivers to the sea. Thus, being principally produced in the land, the microplastics end in the ocean (Shen et al., 2020). Besides harming ecosystem functioning, microplastics are contributing to another global environmental threat: climate change. Plastics have a significant carbon footprint, contributing 3.4% of global greenhouse gas emissions throughout their lifecycle (OECD, 2022). In 2019 alone, plastics generated 1.8 billion tonnes of greenhouse gas emissions, with 90% coming from their production and conversion from fossil fuels. Microplastics have a share on this footprint. Being so small one could not imagine that microplastics are

linked with climate change, but many models demonstrate they are contributing to significant releases of greenhouse gases over time when they break smaller (Shen et al., 2020), and especially they are a major threat to ocean carbon sequestration because they reduce the rate of photosynthesis by marine phytoplankton (Sharma et al., 2023).

While the environmental microplastics pollution and its globally negative effects on the ecosystems are undeniable, its impact on humans is under discussion. Some scientific voices claim microplastics have not proven to be dangerous for humans yet. Wang et al. (2019) argued that there is a lack of robust data quantifying the exposure levels of microplastics for humans, thus it is difficult to reasonably evaluate the actual implications of microplastics to human health. The majority of microplastics that enter the human body would be naturally expulsed, and for those that may remain there are insufficient cause-effect evidences of health harming (Brachner et al., 2020, Smith et al., 2018). Opposite to that, other scientific voices recognize different adverse effects of microplastics that have been tested in animal models (Koelmans et al., 2022; Prata et al., 2020). The most relevant effect mechanisms, with a serious weight of evidence, are food dilution (inhibited food assimilation or decreased nutritional value); internal physical damage; external physical damage; and, with lower certainty, oxidative stress (de Ruijter et al., 2020). In other animals, microplastics are known to produce a variety of other problems that can be extrapolated to humans, such as DNA damage, carcinogenicity, and developmental toxicity (Yuan et al., 2022). From those evidences experimentally tested, researchers infer that the exposure to microplastics poses a credible risk for human health, either inhaled and/or ingested.

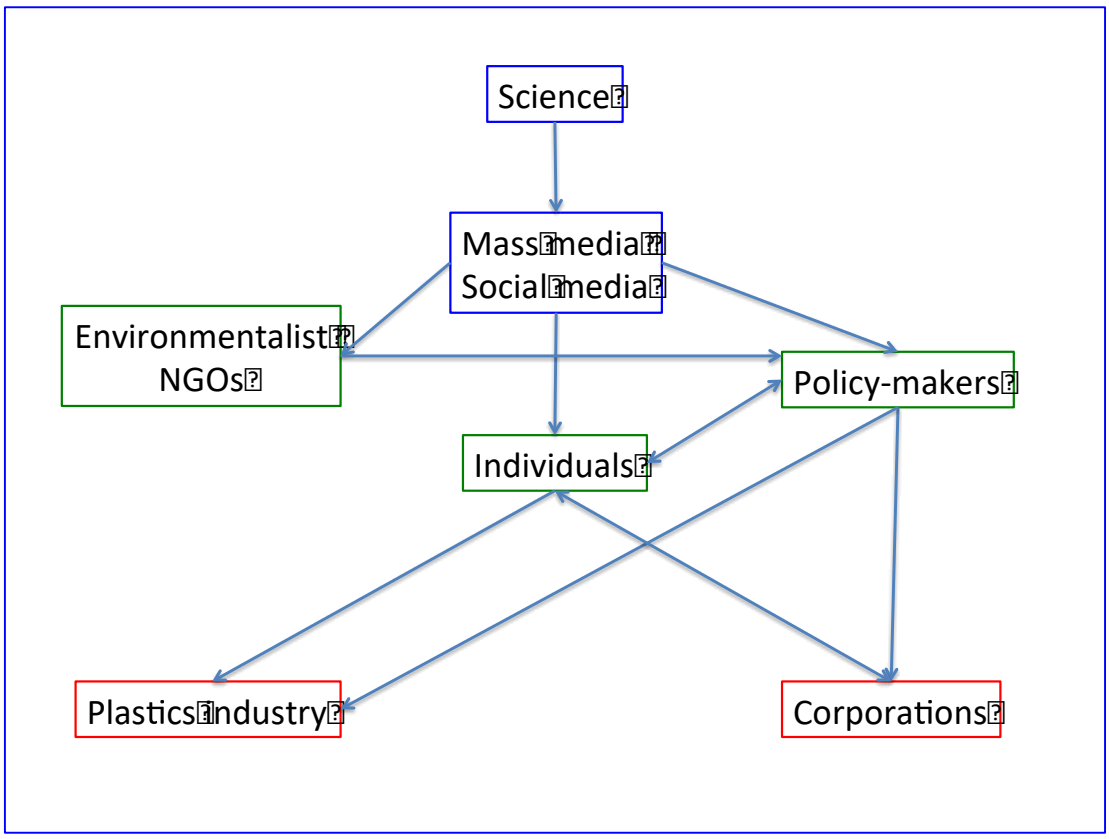
Protecting oneself from microplastics is extremely difficult because they have been found in all the human food types and drinking water sources analysed to date (Singh et al., 2022); while hygienic masks might prevent microplastics inhalation, humans still need to eat and drink. Being produced by humans, only humans can solve this problem. It is time to adopt behaviors, as a society and individually, to stop this emerging pollutant preventing its entrance in the ecosystems for the sake of human and environmental health. This is the reason that justifies the present Thesis within the Doctorate Program on Health Psychology.

1.2. The actors in the microplastics crisis

As a global challenge, the microplastics crisis scenario is complex and involves the whole society. From their many uses and global applications, there are important economic interests involved in the production of plastics and microbeads. The revenue of the plastics industry is huge since global plastics production has been grown relentlessly in the last decades. The **plastics industry** is vital for Europe's economy and its recovery plan and is one of the main actors in the microplastics crisis (Figure 1.2). Together, the plastic raw materials producers, plastics converters, plastics recyclers, and machinery manufacturers, represent a value-chain that employs over 1.5 million people in Europe, through more than 55,000 companies, most of the them SMEs, operating in all European countries. In 2019, these companies created a turnover of over 350 billion euros and contributed to more than 30 billion euros to European public finances (PlasticsEurope, 2020). Thus, multinational plastics producers are main actors in microplastics scenarios, being fully aware of the pollution derived from their materials. The organization Plastics Europe

(https://legacy.plasticseurope.org/en), a pan-European association that represents plastics manufacturers active in the European plastics industry, has launched the Declaration for Solutions on Marine Litter to create a platform for action. They are committing to adopt improvements to reduce the effects of ocean pollution, with six objectives: Raising awareness, Research for facts, Promoting best practices, Sharing knowledge, Enhanced recovery, Preventing pellet losses (https://www.marinelittersolutions.com/). More specifically about microplastics, they have also started the Operation Clean Sweep® for companies to sign a pledge to prevent resin pellet, flake and powder loss (https://www.opcleansweep.eu/sign-up). Raising awareness and sharing knowledge are directly related with this Thesis.

Figure 1.2. Overview of actors involved in the microplastics crisis.



Besides plastics producers, other companies are involved in plastics consumption and usage in different ways. Companies not related with plastics production or transformation use plastics because they are convenient for packaging, in coffee machines, in furniture and housewear. **All corporations** can act to prevent microplastics pollution through the promotion of environmentally conscious practices in their everyday life and amongst their workers, i.e., corporate environmental responsibility (Dolzhenko & Churakova, 2022). This includes a variety of actions from recycling and reusing plastic items to the use of alternative packaging employing sustainable materials.

As seen above, **the science** has much to say in the microplastics crisis. The presence of microplastics in the environment, food, water and living organisms was discovered by environmental researchers that had adequate tools for the observation of those tiny particles. The first scientific publications about microplastics started in 1986, and until 2010 no more than 10 papers per year were published (Zhang et al., 2020b). The rate of investigations started growing exponentially since then, covering principally areas of natural sciences such as toxicology, environmental sciences ecology, chemistry, engineering, and marine and freshwater biology (Zhang et al., 2020b). Although early authors already recognized the need of psychosocial approaches for the control of this then-perceived novel pollutant (Chang, 2015), very little research had been done in this field by 2019, when the psychosocial research on microplastics crisis was considered to be in its infancy (SAPEA, 2019).

Indeed, **policymakers** are crucial actors in the microplastics crisis. As examples, USA President Obama signed the "Microbead-Free Waters Act" in 2015 (https://www.govinfo.gov/content/pkg/BILLS-114hr1321enr/pdf/BILLS-114hr1321enr.pdf); seven years later (on 30 August 2022), the European Commission agreed a proposal to restrict the placing on the market of microplastics, including where they are added to certain products (https://ec.europa.eu/transparency/comitology-register/screen/documents/083921/1/consult?lang=en). Pro-environmental laws like single-use plastics and microbead bans are instruments that can serve for microplastics control in some countries (Anagnosti et al., 2021; Patricio Silva et al., 2020), although they are not equally useful everywhere. As an example, the top-down policy implementation is not reducing microplastics burden in Africa (Deme et al., 2022). Bottom-up strategies such as public-private cooperation has been proposed instead as a good strategy for microplastics control. Promoting and incentivizing shifts towards circular economy could be achieved through tax breaks, for example for those companies that produce or recycle reusable bags as it happens in South Africa (Deme et al., 2022). Although waste trade is regulated by the Basel Convention (United Nations, 2018), counterexamples of bad practices could be exports of plastic waste to third countries, which is a paradigmatic *not in my backyard* policy of European and North American countries (van der Marel, 2022). At least in Europe these practices are expected to be cut soon, since the EU Parliament has backed on January 2023 the adoption of stricter rules for waste shipments (https://www.europarl.europa.eu/news/en/press-room/20230113IPR66627/waste-shipments-meps-push-for-tighter-eu-rules, accessed on April 2023).

For many researchers, the **individuals as consumer citizens** are in the core of the plastics and microplastics crisis (e.g., Henderson & Green, 2020; Marazzi et al., 2020). They can make pro-environmental choices, like not littering and sorting waste. As consumers they may decide what and how to buy: single-use plastic or reusable goods, products with or without microplastics. As citizens they may get informed and participate in environmental care, like clean-ups or campaigns to raise awareness about plastics control. These individual behaviours are an important focus of psychosocial research. Behaviors required to fight microplastics are not the same for the primary and secondary ones. The most efficient behavior to stop pollution from primary microplastics for individual consumers is not to buy products containing plastic microbeads i.e., refusing consumption (Figure 1.3). Avoiding glitter seems to be very easy because it is merely decorative and can be replaced for coloured substances of vegetal origin, although the majority of consumers do not identify

glitter as microplastics (Yurtsever, 2019). To stop secondary microplastics there are only two possible ways: to stop consuming and employing plastic, and, if plastic is used, to dispose it in a sustainable way that do not contribute to pollution anymore.

Between the science, the policy-makers and the individuals (Figure 1.2) there is the so-called third power: the **mass media,** and more recently the **social media** (Sujata et al., 2019). For Schäfer (2008), a growing number of mass media articles are reporting on scientific knowledge; at the same time, an increasing number of societal stakeholders comment on scientific knowledge in the media; and, reporting on scientific knowledge is increasingly polarized, as the mass media both embraces and criticizes scientific knowledge. In the microplastics crisis, media play a key role of transmission of scientists' knowledge and opinions because microplastics are invisible and people gets the information about them from media (Schönbauer & Müller, 2021). Völker et al. (2020) suggested that the narratives transported by the media trigger public concerns, for example about microplastics in food, transforming an uncertain risk into an actual risk. These authors explained it because the likelihood of harmful consequences and knowledge gaps regarding the consequences are not presented in a balanced way. On the positive side, the mismatch between few studies of scientifically confirmed risk and widespread public perception of microplastics-derived health risk, has been highlighted by Catarino et al. (2021) as an opportunity for a more sustainable plastics economy.

Finally, **environmental activists and NGOs** have a role in the microplastics crisis. Activists in environmental groups are generally better informed about microplastics than other citizens that may see the problem very far (Anderson et al., 2016). The support of NGOs in the promotion of recycling activities is advantageous for the materialization of recycling behaviour (Sujata et al., 2019). Nielsen et al. (2020) explained that in the plastics life cycle littering and pollution –at the end of the cycle- are more likely to be understood as a societal problem in scientific literature and suggested that it is partially due to the materiality of objects like microplastics. For these authors, microplastics and other plastic objects make plastic politics tangible, which is essential for mobilizing political action: they provide focal points for social movements and NGOs targeting plastic consumption. Nielsen et al. (2020) called it *politicization* of microplastics.

The four R's hierarchy (reduce, reuse, recycle, recover) was proposed for waste management (Prata et al., 2019). It can be expanded to the 10R imperatives (Figure 1.3; see also Reike et al., 2018). At an individual level, refuse and repurpose would be encouraged in addition to reduce, reuse and the first part of recycling, while the rest of R-imperatives would be relevant for the plastics industry or related corporations. To complete recycling the industry is also needed, because the majority of consumers can sort plastic litter and dispose it in proper containers, but not transform it into another good or material.

Figure 1.3. The 10-R imperatives and actors to whom they may apply.

R's	Value Retention Options	Main actor
R0	Refuse: buying and consuming less plastics products.	Consumer
R1	Reduce: reducing plastic usage.	Consumer
R2	Resell/Reuse: reusing packaging & plastic objects.	Consumer
R3	Repair: repair components when broken.	Industry
R4	Refurbish: improving components of a product or building.	Industry
R5	Remanufacture: using parts of discards in a new product.	Industry
R6	Repurpose: reusing discarded good for another function.	Industry / Consumer
R7	Recycling: obtaining secondary raw materials from a post-consumer product.	Industry / Consumer (litter sorting)
R8	Energy recovery: recovering energy treating plastics.	Industry
R9	Re-mine: retrieving waste plastics by landfill mining.	Industry

The complexity of actors makes the scenario to evolve rapidly, sometimes due to conflicts involving two or more stakeholders, and sometimes to the demand of one or more actors. To mention a few, the industry signed a statement on the single-use plastics guidelines published by the EU Commission on 31 May 2021 (SUP Directive) manifesting their concern about risks of fragmenting the Single-Market during its transposition, and of unintended negative consequences for the consumers e.g. compromising hygiene and safety, or increasing food wastes https://issuu.com/plasticseuropeebook/docs/industry_statement_on_sup_guidelines_-_final (accessed on April 2023). In the USA, microbead bans were fought fiercely for example in California, by Johnson & Johnson company, who argued that the ban was too restrictive and inhibited innovation (Nielsen et al., 2020). Concerns over cross-contamination caused by reusable containers and bags have been raised by the plastic industry (Schnurr et al., 2018), leading to withdrawals or postponements of SUP bans and fees. More recently, during COVID-19 pandemics, consumers' behaviour shifted towards a significant increase of demand for food packaging, mostly driven by hygiene concerns (Jribi et al., 2020). As a consequence, some governments delayed SUP bans (e.g., some Canadian provinces, some states in the U.S., the United Kingdom and Portugal), while others reintroduced SUPs and even banned the use of reusable alternatives (e.g., the states of Massachusetts and New Hampshire in the

U.S.). Patrício Silva et al. (2020) underlined the need to reinforce plastic reduction policies and to implement them into action without delays. Improved communication has been emphasized to help all stakeholders develop effective solutions to mitigating plastic waste and indirect sources of microplastic pollution (Onyena et al., 2021).

1.3. Psychosocial perspectives and tools on microplastics research.

From the invisibility of this emerging pollutant and the complexity of the actors involved, the psychosocial aspects related with microplastics are a novel, underexplored field in between social psychology, environmental psychology, and communication sciences. An overview of the process that an individual, organization or corporation will have to follow to act against microplastics, and the factors involved in that process, is summarized in Figure 1.3.

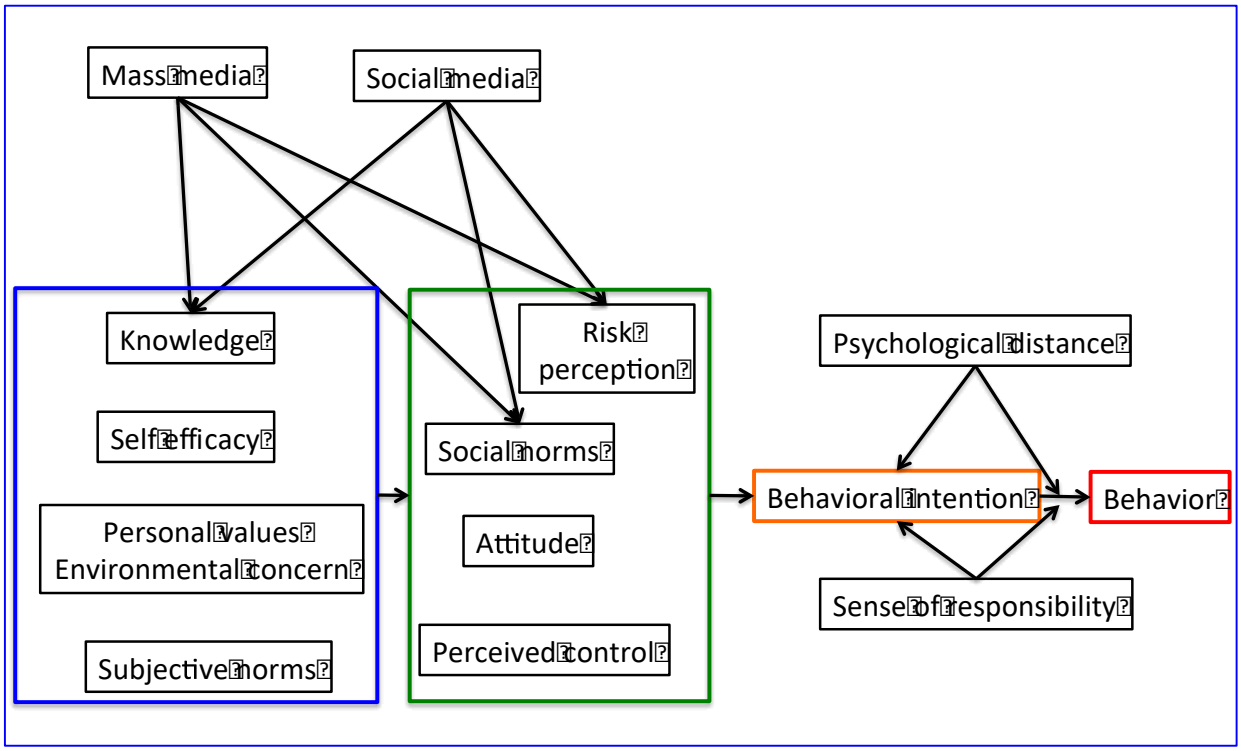
First comes understanding. To know about microplastics, the individual has to hear and understand scientific messages based on facts, generally transmitted via mass and/or social media, disentangling them from opinions of environmentalists, the industry, politicians, and the own interpretations of journalists.

After knowledge and understanding of microplastics comes the awareness of their consequences (risk perception) to put a sign, generally negative or disfavourable, on microplastics pollution (attitude).

Then motivations to act will be needed. Even if we know what are microplastics and are aware that they may be harmful for the humans and the environment, to change our behavior we require something more. We have to care about the environment and our health (if we don't care, why acting? – personal or corporate norms, environmental concern), convince ourselves that we can do something useful (locus of control), that because our actions matter (self-efficacy) we should act (behavioral intention); that us, our neighbors and families will benefit from our action (psychological distance) and the society where we live approves them (social norms); and/or that we are responsible for the environment (sense of self responsibility, intertwined with personal norms).

Depending on our principles, personal experience, interests and relationships with the nature, some reasons will be more important than others for us to change our behavior.

Figure 1.4. Psychosocial and other factors recognized from relevant literature to be involved in the microplastics crisis.



The complex process of social psychology described above is explained from several **psychosocial theories** that should be seen not as opposite but complementary. One of the most widely applied in the recent field of microplastics is the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and its further development as the Theory of Planned Behavior (Ajzen, 1991; Ajzen, 2002; Ajzen & Madden, 1986). These theories that are main pillars of this Thesis and will be explained in Chapters 3-7. Briefly, after knowing an environmental challenge the individual behavioral intention is determined by subjective norms, attitude, and perceived control. A couple of examples from countries of different cultures where the applicability of the Theory of Planned Behavior was confirmed were the individualistic USA and the collectivistic Thailand. Attitude and behavioral control influenced significantly the intention to purchase clothes without microfibers in the USA (Nam et al., 2017). The Theory of Planned Behavior was extended by Mohiuddin et al. (2018) adding values, social norms, and feelings of guilt in Thailand.

In the Value-Belief-Norm theory, which is clearly related with the extension of the Theory of Planned Behavior proposed by Mohiuddin et al. (2018), pro-environmental behavior is predicted from values, awareness of consequences, ascription of responsibility, and personal norms (Chen, 2015; Stern, 2000). Henderson and Green (2020) validated this theory for plastics consumption behavior that increases microplastics: when plastic was valued as hygienic (thus positive) its consumption was not reduced, even for people aware of plastics pollution.

The effect of the psychological distance (the shorter the more important), the risk perception (the higher the more important) and the sense of self-responsibility or feelings of guilt (the more the higher likelihood to act) were confirmed for the intended control of microplastics in different studies (e.g., Herweyers et al., 2020;

Jeong et al., 2021; Soares et al., 2021; Wang et al., 2020; more examples in Chapter 3). However, the perceived risk was not significant in the results obtained by Deng et al. (2020), leaving a question mark –perhaps due to cultural differences between countries– for this factor.

The importance of the media highlighted by Völker et al. (2020) and Schönbauer and Müller (2021) is also supported by psychosocial theories. The Social Cognitive Theory (Bandura, 1991), where social factors affect the operation of the self-regulatory system, and the Cultivation Theory (Gerbner et al., 2002), where it is explained how television contributes to viewers' conception of social reality, have emphasized the role of communication in disseminating norms to a social group. In the last decade, the usage of social media has been added to this scenario as a source of information as seen above, but also as a way of learning social norms about environmental issues (Sujata et al., 2019).

Psychosocial research about the microplastics crisis has employed a **variety of tools**, aligned with the methods common in environmental psychology. Explained in Chapter 3, some of them are briefly commented next.

Surveys (online or face to face) have been the most commonly employed method of psychosocial research about microplastics. In the Chapter 3 of this Thesis there is detailed information about the target participants, the countries where that type of research had been carried out by 2021, and the conclusions obtained from the different surveys. To mention a few examples: Abate et al. (2020) in Norway, Choi and Lee (2018) in Korea, Deng et al. (2020) in China, Didegah et al. (2018) in Canada and Denmark, Misund et al. (2020) in Germany, Norway and Portugal, or Nam et al. (2017) in the USA. Original online surveys were also designed and conducted in this Thesis (Chapters 5 and 6).

The awareness about the microplastics crisis has been explored through mental models. Mental models explain how people see environmental issues and can guide policy support and individual behavior in response to environmental challenges like plastics pollution (Phelan et al., 2020). In the microplastics crisis, a mental models approach based on free associations has been applied in Norway to investigate the public understanding of microplastics, revealing differences between genders, age and educational levels in the ways of thinking about microplastics. Female and young respondents would think more about microplastics sources, and those with a higher educational level would think more on possible solutions (Felipe-Rodriguez et al., 2022).

Focus groups has been another approach employed by several researchers. As an example, Henderson and Green (2020) explored the understanding of plastics and microplastics pollution in the UK working with groups of people from a variety of social backgrounds and emphasized the central role of media storytelling to bring the plastic pollution to public attention. Images of animals suffering from plastics pollution were vividly recalled by the participants, that also emphasized the credibility of scientists, communicators and some popular environmentalists. Another example was Anderson et al. (2016) study. Working with focus groups, they found that for the majority of the society microplastics lacked immediacy and visibility, with the exception of environmentalists. The importance of communications with the public and the industry was the concluding remark of these authors.

Finally, only a few experimental studies had been conducted at the beginning

of this Thesis, aimed at evaluating interventions to successfully promote pro-environmental behaviours towards microplastics. The majority were based on interventions where the subjects were exposed to information about microplastics pollution and its sources, like Chang (2015) in her investigation about the refusal of products with microplastics in the USA, Cammalieri et al. (2020)'s intervention to increase the awareness about microplastics in Italy, or Raab and Bogner (2020) to make microplastics visible for German children.

1.4. Knowledge gaps in the field of study

For the novelty of this emerging pollutant there were and still are many gaps to fill in the study of psychosocial aspects involved in its control. When this Thesis started in 2020, as commented above the social research about the microplastics crisis was recognizedly in its infance (Onyena et al., 2021; SAPEA, 2019; Völker et al., 2020). The psychosocial research landscape was still undefined, and to depict it was the first task of the present Thesis (Study 1, Chapter 2).

In 2020, little was known about the geographical width of psychosocial studies on microplastics. The relative importance of knowledge, sense of responsibility, personal and social norms had been studied only in a handful of countries. The cultural aspects –how collectivists and individualist cultures were approaching this difficult, invisible enemy? - had not been tackled yet. The second task of this Thesis was to conduct a meta-analysis to understand the state of the art in this field, with a focus on the geographical and cultural coverage of the studies published so far, and on the psychosocial aspects and theories involved (Study 2, Chapter 3). From the results of that meta-analysis, it was expected to identify new gaps and research needs to further undertake original research to fill in those gaps.

The map of actors and their respective weight on microplastics control was still unclear at the beginning of this Thesis. Some actors were certainly understudied. What was the role of mass media? In one of the few studies describing media foci in the field of microplastics, Völker et al. (2020) discussed how science contributes to the media discourse but have not explored the universality of this phenomenon being their study focused on UK newspapers. In Germany, where there is clear mismatch between the scientific risk and the public risk perception of microplastics (Kramm et al., 2022), the risk seemed to be emphasized in media discourses only at the beginning of the studied period (by 2010), but after 2015 risk assessments diverged because voices from different actors were heard (Schönbauer & Müller, 2021); moreover, the individual responsibility of the consumer was accentuated by media over time. From these two examples in Europe, there is a clear knowledge gap about the role of media in the public perception of microplastics, especially at a global scale. It was addressed in the third task of this Thesis (Study 3, Chapter 4).

The United Nations Sustainable Development Goal #14 is "*Conserve and sustainably use the oceans, seas, and marine resources for sustainable development*". As explained above, there is no doubt the plastics pollution is hampering that goal. Misdisposed single-use plastics are responsible for a big proportion of the microplastics that harm currently marine species (Wayman & Niemann, 2021). Many people use ocean resources not only for food, but also for energy, transport, sport, leisure; so, developing a feeling of attachment to and responsibility for the oceans that have been coined as *marine citizenship* (McKinley & Fletcher, 2012). Despite a considerable number of studies about the enormous threat of single-use plastics for

the ocean (Chassignet et al., 2021), the relationship between the marine citizenship and the single-use plastics consumption and recycling had not been sufficiently investigated. The four task of this Thesis (Study 4, Chapter 5) was to address this topic in countries from regions with different loads of marine plastics pollution, using online survey methodology.

Nielsen et al. (2020) stated that the scientific literature on plastics pays insufficient attention to how the plastic is bound up with our dominant systems of production and consumption, thus facilitating and maintaining societies of disposability and overconsumption. They highlighted the need to study and confront the systemic, large-scale economic and political arrangements, as well as the governing norms and practices, which stabilize unsustainable patterns of production and consumption. To address this research need, this Thesis focused on the effect of legislations about microplastics beads on the public willingness to control microplastics (Study 5, Chapter 6). A multinational online survey was conducted in countries with different laws on microplastics bans.

From the scarcity of experimental studies on behaviors related with microplastics emissions, it was clear that this was a big research gap. Pahl and Wyles (2017) emphasized the need for experimental quantitative approaches comparing randomised groups to study cause–effect relations in the field of behaviors conducent to microplastics control. In this Thesis an experiment based on randomized groups exposed to different nudges was conducted (Study 6, Chapter 7).

Best practices of ethics in research were carefully followed with the permit of the competent Committee of Research Ethics of Asturias Principality, reference CEImPA:2021.116. Regarding the presentation of the six studies that compose the Thesis, they follow the structure of academic articles. Specific departure hypothesis and expectations are provided in each study. The methodology employed is described study by study as well.

1.6. Objectives / Objetivos

The main objective of the Thesis was the identification of behaviors and strategies that drive the control of microplastics in the current global scenario. The specific objectives were:

i) To identify current problems, proposed solutions, and research needs about psychosocial aspects of the microplastic crisis using mismatches between perspective articles and reviews as a source of information.

ii) From the analysis of current literature, to identify main psychosocial frameworks involved in the microplstics crisis and determine how they could be applied in the mitigation of that global environmental crisis, from the analysis of current literature.

iii) To investigate intercultural differences in how and when mass media introduce microplastics issues into the public discourse.

iv) Being plastics pollution one of the main sources of microplastics, to explore how marine citizenship (sea frequentation and the feeling of responsibility for the ocean) influences the consumption of single-use plastics (SUP) in countries with different social norms about SUP: Mexico and Spain.

v) To reveal possible differences between Mexico and Spain on the behavior and behavioral intentions about microplastics control, having Mexico a much stricter legislation than that of Spain regarding microplastics bans.

vi) To determine if the online exposure to nudges (images plus short sentences) related with microplastics is sufficient to promote the willingness to adopt R-behaviors for their control, and what type of image subjects are more efficient.

El objetivo principal de esta Tesis doctoral es la identificación de conductas y estrategias que conduzcan al control de microplásticos en el escenario global actual. Los objetivos específicos son:

i) Identificar los problemas, soluciones propuestas y necesidades de investigación actuales sobre los aspectos psicosociales de la crisis del microplástico, mediante un análisis de discordancia entre artículos prospectivos y revisiones como fuente de información.
ii) Mediante el análisis de fuentes bibliográficas actuales, identificar los principales marcos psicosociales implicados en la crisis del microplástico, y determinar cómo podrían aplicarse a la mitigación de dicha crisis.
iii) Investigar diferencias interculturales respecto a cómo y cuándo introducen los medios de comunicación los problemas del microplástico en el discurso public.
iv) Siendo la contaminación por plásticos una fuente principal de microplásticos, explorar cómo la ciudadanía marítima (frecuentar el mar y sentirse responsible de él) influencia el consumo de plásticos de un solo uso en países con distintas normas sociales al respecto: México y España.
v) Desvelar posibles diferencias entre México y España en la conducta e intención conductual sobre el control de microplásticos, teniendo México una legislación mucho más estricta sobre la prohibición de microplásticos.
vi) Determinar si la exposición online a *nudges* (imágenes más frases cortas) relacionadas con microplásticos basta para promover la intención de adoptar conductas R para su control, y qué tipo de temática es más eficaz.

CHAPTER 2

STUDY 1: WHAT WE NEED TO KNOW. PSYCHOSOCIAL RESEARCH IN THE FIELD OF MICROPLASTICS

Publication:

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2.1. Abstract

Current human lifestyle generates enormous amounts of plastics and microplastics that end in the ocean and threaten marine life. Exposure to microplastics seems to threaten human health too. Although the degree of damage is not clear yet, precautionary approach urgently requires a change of societal habits. The objective of this study was to discover emerging issues of priority for psychosocial investigation. For this we have compared the landscape research of Reviews with that of Perspectives articles of the last decade, to identify mismatches that unravel still understudied subjects. Results revealed that circular economy is a focus in Perspectives but is not main topic of current psychosocial research. Regarding the actors involved in the change towards circular economy, although companies are priority in Perspectives current research is focused on consumers. Results suggest the need for more efforts on the investigation of corporative responsibility in the way to stop microplastics pollution.

2.2. Introduction

The first target of the UN Sustainable Goal 14 "Life below water" is the significant reduction of marine pollution of all kinds, including plastics debris. Microplastics pollution undermine this desired goal. The current microplastics crisis could be defined as a sustained increase of small plastic particles (< 5mm) in the air (Zhang et al., 2020), soil (Xu et al., 2020) and water worldwide (Li et al., 2020). These particles come from the degradation of larger plastics, fibers from plastic clothes and fabrics (secondary plastics) or are produced in purpose for scrubs, hygiene products, cleaners and others (primary microplastics).

The problem is especially complex when one takes into account its global dimension (Hale et al., 2020). Solutions must be taken urgently because the impacts of microplastics in nature are enormous, as we will see below, and also because human health is at stake: inhaling and eating microplastics and their adhered compounds may produce from inflammatory responses to cancer (reviewed by De la Torre, 2020). Being produced by humans, microplastic accumulation can be stopped by humans only, as long as they change their consumption habits and behavior. One could expect interventions aimed at societal behavioral changes to be a priority, but research on psychosocial aspects involved in the microplastics crisis is still in its infancy (SAPEA, 2019). This study will try to contribute to identify main actors and psychosocial intervention strategies that need urgently further research using reviews and perspective articles as source of information.

2.2.1. Actors and psychosocial determinants in the microplastics crisis

Actors in the microplastics crisis are indeed humans. Plastic and microplastics are produced by industry because consumers buy and use them, and vice-versa. Used plastics, and microplastics wastes, end in the oceans because citizens and companies do not dispose litter properly, sometimes because there are no public facilities to easily dispose waste, and/or because existing facilities (like landfills or wastewater treatment plants, WWTP) do not have adequate technology to prevent microplastics to enter the environment (Freeman et al., 2020). Microfibers, that are the most abundant type of microplastic in the ocean, are shed from textiles and clothes and transported by wind currents through the atmosphere, being finally deposited on seawater - the majority by rainfall (Roblin et al., 2020). They also come from laundry for the lack of

tertiary treatments in WWTP (De Falco et al., 2019). Thus at least companies, consumers and managers are directly involved in the production and emission of microplastics. Indirect actors like politicians are responsible of spending public money in technology for waste treatment, and also of the design and application of more or less strict legislation to prevent plastic pollution, including the promotion of circular economy or restrictions to single-use plastics using levies and bans (Da Costa et al., 2020).

Psychosocial issues involved in the microplastics crisis are as diverse as the actors. Consumers are perhaps the main direct responsible of microplastics pollution, but they are often unaware of the existence of microplastics in the products they buy. For the unnatural condition of microplastics and their adverse effects on flora, fauna and human health, perhaps consumers would avoid products of personal hygiene and cleaners with microplastics - if they were aware of them (Chang, 2015); although many consumers would not but microplastics-free product if they have to pay more for them (Misund et al., 2020). Secondary plastics are a different issue because they originate from larger plastics, but consumer awareness would be also essential. Despite its many qualities that make plastic convenient, like lightness and cheapness, consumers would probably reduce the use of plastic if they knew that it often ends in microplastics (Deng et al., 2020). Thus, knowledge and awareness of risks posed by microplastics would be, in principle, useful to change consumer's behavior.

Companies that produce microplastics are main actors too, but most studies to date have not been directly focused on them. Indeed, if conventional plastics were replaced for other materials of similar properties microplastic emissions would stop. For this, the environmental sustainability of the alternative materials throughout all their life cycle – from cradle to grave- must be carefully assessed before proposing them. However, acquiring new technologies and finding new niches of providers and customers is difficult and has a cost for the company; these are main objective barriers for sustainable plastic management by the private sector (Dijsktra et al., 2020). In face of the control of plastic waste, companies prefer recycling rather than reusing and reducing (Rhein & Sträter, 2021); such preferred option encompasses fewer changes for the company but is less environment-friendly because plastic waste is produced anyway. Adopting environmental innovation behavior has a larger effect on environmental than on economic performance in a firm (Long et al., 2017), but on the other hand, having a green image is important and promotes changes towards environmental sustainability. Firms that adopt green product and green process innovation have a better financial performance if they have a green image (Xie et al., 2019). For Lasrado and Zakaria (2020), in addition to a green organizational culture, regulations, rewards, and incentives ensure that green initiatives will be implemented in organizations; this implies costs for the companies but at the same time the potential benefit of promoting a green image. Thus, there is a plethora of factors influencing corporate behavior that could affect, positively or negatively, the emission of microplastics.

2.2.2. Contextual settings: sources, sinks and dimensions

The microplastic crisis is multidimensional and has profound international implications. Prata et al. (2021) highlighted microplastic contamination as a problem of public health and social justice. They interpret the accumulation of microplastics as a symptom of large public health problems, like lack of wastewater treatment infrastructures that affects countries and continents unequally being Africa the most

affected. In a recent review about the efficacy of wastewater treatment plants for the retention of microplastics around the world there was no one single example from Africa (Hamidian et al., 2021).

In the spatial dimension, sources are everywhere, and ocean sediments are the ultimate sinks of microplastics (Hale et al., 2020). Sources of microplastics are all the elements and tools partially or totally made of plastic that are employed in practically every economic and population sector: agriculture, fishing, transport, industry; large urban concentrations and small villages in all the continents. Used plastics and microplastics produced in land, if not properly collected, recycled and treated, end in the watercourses and go to the sea; expectation is that the plastic making its way into the ocean doubles by 2025 (e.g., Jambeck et al., 2015; Usman et al., 2020). In the ocean, where microplastics finally accumulate, they can be found from the abyssal plains (Abel et al., 2021) to the remote Antarctica (Sfriso et al., 2020). Microplastic ocean pollution implies a threat for living beings from bacteria to fish (Ajith et al., 2020), and is endangering some fishing resources already (Ferreira et al., 2018).

In the psychological dimension, at least two aspects are important. One is related with the use of natural spaces. Ocean microplastic pollution can be a source of psychological discomfort for human users and visitors. In their study in Canada, Engel et al. (2021) found at least 282 different ways in which people imagine the ocean, from which the five most frequent were beautiful, fishing, cold, pollution and vast. Ocean images correlate with emotion, cognitions and pro-environmental behaviors (Engel et al., 2021); a polluted image produces negative emotions. On the other hand, the society perceives the risk derived from microplastics, especially those present in food and seafood (Catarino et al., 2020). For some authors, risk perception has been alimented by some sectors like media and environmentalists with insufficient proofs of real harmful effects of microplastics on human health (Volker et al., 2020). However, the diverse undeniable damages caused by microplastics in other organisms of all taxonomic levels (de Sá et al., 2018) strongly support the idea of real risk for humans.

2.2.3. Control attempts: legislation, policies and psychosocial interventions

Today, efficient, and practical solutions to clean up microplastics pollution from the environment, in particular from the oceans, have not been invented yet. What can be done is prevention, control of emissions and mitigation measures like technical improvements in WWTP (e.g., Hamidian et al., 2021; Masiá et al., 2020). There are several initiatives to control microplastic pollution at national and international levels through policies and legislation. The production of primary microplastics is banned or limited in some countries (e.g., Dauvergne, 2018); the United Nations Environment Program (UNEP) has passed non-binding resolutions on marine microplastics that perhaps merged with other instruments could speed up the control of this global stressor (Tiller & Nyman, 2018). All strategies applied for the control of plastic waste contribute indirectly to control microplastics, cutting the source of secondary microplastics that is plastic waste. An example is the EU directive on single-use plastics (European Union, 2019); another is the UNEP initiative called Clean Seas, a platform to connect individuals and stakeholders for catalysing a change needed to reduce marine litter around the world (https://www.cleanseas.org/, accessed July 2021). On the other hand, the international waste trade is regulated in the Basel Convention (United Nations, 2018). Researchers currently discuss plastics governance, which, although it is not easy, seems to be possible. Public will, effective

policies and coordination to work on global, national, local, and individual levels are needed to manage marine plastics (Vince & Hardesty, 2018). Tessnow-von Wysocki and Le Billon (2019) identify key elements to be employed in international treaty designs to cut down marine plastics pollution, like the adoption of principles of common but differentiated responsibilities, or linking pollution to international plastics trade, amongst others. Raubenheimer and Urho (2020) propose a global extended producer responsibility scheme to apply the Polluter Pays Principle on the management of plastic pollution at a global level.

Indeed, these top-down initiatives will be efficient only if they are accompanied by individual and corporate behaviour of microplastics prevention. Reality shows that illegal dumping and uncontrolled plastic waste are sadly occurring at high levels in developed (Law et al., 2020) and developing countries (Bundhoo, 2018). For the key role of individual behaviour in the production of uncontrolled plastic waste, microplastics pollution could be diminished using interventions at psychosocial level; however, these are still extremely scarce. In the literature only a few examples can be found of intended behaviour changes to reduce microplastics. Behavioural intention changes are produced after exposure to information about microplastics impacts in children (Raab & Bogner, 2020), university students (Cammellieri et al., 2020; Chang, 2015), and general public (Deng et al., 2020). Exposure to this type of information also increases the intention of purchasing green clothes (Nam et al., 2017) or devices to prevent microplastics escapes from laundry (Herweyers et al., 2020).

The complexity of this multidimensional subject would require solutions involving many actors. The collaboration of different population sectors seems to be a best practice for the purpose of microplastics mitigation. Prata et al. (2021) suggest stakeholders to introduce their day-to-day experience to the challenges posed by microplastics and provide guidance in mitigation measures like beach cleaning. Multidisciplinary teams are essential to obtain relevant data because the impacts of microplastics are a cascade that affects the interdependent systems of environmental, biotic, and human health (Prata et al., 2021).

For tackling a subject as complex as the psychosocial aspects of the microplastic crisis, such as the relationship between sea and human health, Short et al. (2021) highlighted the need of systematic reviews. Systematic review methods can provide the highest levels of robust evidence, so policymakers are best informed in decision-making and able to assess timely policy needs. Here we will use existing reviews and perspective articles. Reviews are articles where current research is compiled and summarized, while perspectives or focus articles generally intend to identify emerging topics within a field that deserves special attention, for their novelty or because they have not been sufficiently explored yet.

2.2.4. Objectives and departure hypothesis

The main objective of this study was to identify current main problems, proposed solutions, and research needs about psychosocial aspects of the microplastic crisis, using mismatches between perspective articles and reviews as a source of information. For this we carried out an analysis of research landscape based on the use of relevant terms, their frequency and connections, and a comparison between the topics tackled by each type of article. We expected to find priority emerging topics in perspective articles, while the subjects that are really investigated would appear in reviews. The mismatch will indicate what are the most urgent research needs and directions.

2.3. Methods

2.3.1. *Literature search*

PRISMA methodology (Mohrer et al., 2009) was the basis to find relevant reviews and perspective articles about psychosocial issues in the microplastics crisis. Limits to geographical location, publication year or language were not applied, although the search was done in English. Date of search was April 2021. Online databases consulted were ERIC, Google Scholar, PsycINFO, PubMed, ScienceDirect and Social Sciences Citation Index, plus a manual forward search and a backward search from references cited in selected reviews.

We used the following search terms: Microplastics, microfibers, microbeads, MP (acronym of microplastics), pollution, psychology, psychosocial, review, perspectives, focus. We used the Booleans "AND" and "AND/OR" to retrieve principally reviews and perspective articles containing both psychological and environmental subjects. The terms "microplastics", "psychology", and "review" or "perspectives" were employed simultaneously in all searches. Considering the enormous volume of recent articles about microplastics published in environmental sciences were tried to follow a conservative search strategy in order to exclude information limited to the environmental point of view. For this, the Boolean terms used in search were: "AND" for at least one microplastic-related and one psychology-related terms were employed, to retrieve as many as possible relevant references; "AND/OR" when multiple terms referred to any of the two main topics (microplastics and/or psychology) were employed together in the same search.

Quality filters for eligibility were:

1) Peer reviewed academic articles or reports issued by internationally recognized institutions like Academies, FAO, UN, UNESCO.
2) Admissible study designs: reviews, perspectives, focus articles.
3) Topics being researched: any psychosocial trait and any type of microplastic.
4) Time range: no limits were set.
5) Language: no limit was set, but the search was done in English thus most articles retrieved were in English.
6) Article status: published or accessible online in the journal website ahead publication.

Exclusion criteria were (in addition to a failure to comply with the inclusion criteria above):

1) Conference communications.
2) Books without peer-review.
3) Unpublished theses and dissertations.
4) Articles published in popular science magazines.
5) Articles published in media and social media.
6) Articles in repositories ahead peer-review (e.g., arXiv).

2.3.2. *Data collection*

The data of the studies included in this article were extracted into a form organized in spreadsheet format. The following data were collected from each eligible article:

1) Digital object identifier (DOI).
2) Internet link where the article can be found.
3) Authors.
4) Year.
5) Journal, book or e-book.
6) Title.
7) Summary of the objectives (one to three sentences).
8) Main psychosocial issues considered.
9) Type of article (review or perspectives). For this we classified the articles as Reviews or Perspectives following the self-denomination made by the authors (i.e., when the article is explicitly classified as a review or a perspective article in the title, abstract or by the journal).
10) Number of references employed.
11) Summary of conclusions (one to three sentences).
12) Summary of recommendations (one-two sentences).
13) Key words.
14) Abstract.

2.3.3. Risk of bias in individual studies

No bias risk assessment was carried out because this study was based on published, peer-reviewed reviews and perspectives articles that do not contain original new data. In addition, this subject is very novel, and the number of available studies is limited.

2.3.4. Analysis of research landscape

To visualize the subjects' landscape of reviews and perspective articles, we did a cluster analysis of relevant terms following an expanded version of Klingerhöfer et al. (2020) keyword analysis, using the free software VOSviewer (van Eck & Waltman, 2010). This type of analysis relies first on the identification of relevant terms, then on determining the relationships between them, and finally on the visual representation of the results in a *network map*. The relevance of a term indicates how representative it is of specific topics covered by a text. Relevance is calculated from the frequency of that term and also for its proximity – location in the same text - to other relevant terms. Words with a low relevance score are either infrequent or, on the contrary, very frequent and interspersed throughout different texts. So, they tend to be of a general nature and not representative of any specific topic.

A network map contains the relevant terms (= *items*) and the links between them. A *link* is a connection or a relation between two items. Links indicate how strong is the association between two items, for example how frequently they co-occur in a series of texts or articles. In a network map, the labels that represent the items may be proportional in size to the relevance of the items. The width of links may be proportional to the strength of the link between two items.

A *cluster* is a set of items included in a map. In VOSviewer clusters do not overlap. The items within a cluster are more closely related to each other than to the other clusters – for example, they may tend to go together in a group of texts or articles, but not in others. In a network map, clusters may be represented by different

colors.

Klingerhöfer et al. (2020) employed only keywords in their analysis. Since some perspective articles do not have accompanying keywords, here titles, abstracts and keywords –if present- were considered. The relevance of a term is calculated from Van Eck and Waltman (2011), and an item may belong to only one cluster (van Eck & Waltman, 2010). We employed the options "total link strength" (the total strength of the links of an item with other items) and minimum strength lines of 1 to create a network-based map in the free software VOSviewer version 1.6.15 (van Eck & Waltman, 2010). The following settings were applied: binary counting, four or three minimum occurrences of a term, and 70% of most relevant terms selected.

2.3.5. Analysis of the coverage of emerging topics

As seen above, psychosocial issues involved in microplastic pollution are yet understudied. Emerging topics insufficiently covered with scientific data to date were identified from the comparison between relevant terms of reviews and perspective articles. A three-step analysis of key words, titles and abstracts was done.

In the first step we identified relevant terms employed in each type of article (reviews and perspective articles separately) using the VOSwiever software (Van Eck & Waltman, 2010); as above, but considering two minimum occurrences of a term instead of four or three, in order to enrich the number of relevant terms –given the small number of perspective articles found. Binary counting was applied. Common words like analysis, chapter, country, study or solution, and synonymous (those with fewer occurrences) were excluded.

In the second step, the extracted terms were classified in any of the main categories mentioned in the Introduction above. They were categorized as Policy (legislations, bans, responsibilities), Actors (consumers, producers, polluters), Mitigation tools (recycling, responsible consumption), Psychosocial issues (knowledge, risk perception), Problems (pollutants, environmental risks), Scope (physical settings affected by microplastics) or Sources (sources of microplastics).

In the third step, a comparison between the two types of articles for the distribution of relevant terms in categories was done. Discrepancies between reviews (a compilation of what has been done) and perspective articles (generally dealing with emerging subjects) indicate future directions and urgent research needs. We used contingency Chi Square test – confirmed with exact Fisher's test, and Cramer's V to estimate the effect size. SPSS © version 26 was employed.

2.4. Results

2.4.1. Overview of literature search results

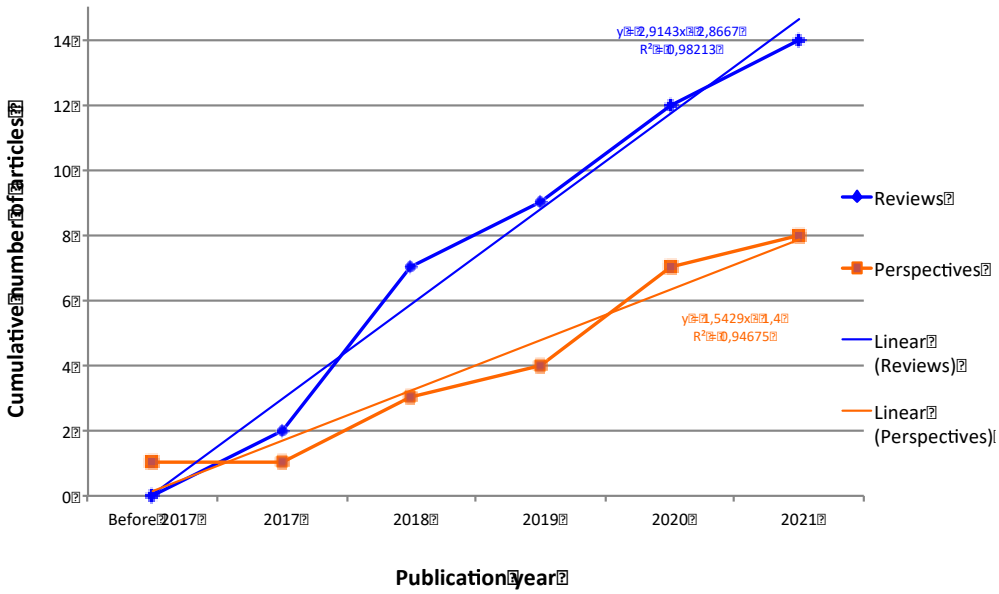
Using all the search terms with Boolean "AND" yielded only 26 raw results, only four of them meeting the selection criteria. Using a combination of "AND" and "AND/OR" Boolean a total of 84 results were found from which 22 (26.2%) met the required criteria (Table 1), being reviews, perspective or focus articles referred to any type of microplastic and psychological view at the same time. Articles focused on general plastic or litter objects that mentioned microplastics only as a potential risk were not retained.

Step	Criteria	Retained	Excluded
Initial search	Online databases (71) & other sources (13)	84	None yet
First filter	Duplicates and non-related	73	11
Second filter	Peer-reviewed and/or authoritative source	63	10
Third filter	Reviews/perspectives articles	31	32
Fourth filter	Microplastics & Psychological issues	22	9

Table 2.1. Flow table summarizing the selection process, showing the number of articles retained and excluded in each step.

Fourteen articles fully assessed were reviews and eight were perspective articles (Table 2.2). Before 2017, only one perspective article was found. Starting in 2017, the number of reviews increased linearly and indeed significantly, being much steeper than the increase of perspective articles (Figure 2.1). In April 2021 (month 4th), there were already two reviews and one perspective article that accomplished the strict criteria required in this study, demonstrating the sustained interest of the academy for this topic.

Figure 2.1. Cumulative number of articles fully assessed in this study, by type (review or perspectives). Equations of the linear trendlines and their R^2 values are displayed in the chart.



The articles retained in this study were published in 16 journals and three peer-reviewed online books (Supplementary Table 2.1). Journals publishing more than one of these papers were the *International Journal of Environmental Research and Public Health* (two articles) and *Marine Pollution Bulletin* (two articles). Some articles were published in journals of wide international impact like *Proceedings of the National Academy of Science USA*, *Nature Communications*, *Environmental Pollution* or *Global Environmental Change*, while other journals had a geographical (*Scientific African*) or ecosystem-specific focus (*Marine Pollution Bulletin*, *Water*). The number

of articles reviewed that appear in the bibliography ranged between 15 and more than 200 (Table 2.2). However, it must be noted that after analyzing their content only a few references contained data about psychological issues directly related with microplastics, as we will see below. The majority of references in all the papers examined were related with behavior about plastics and general trash, and with pro-environmental and sustainable behavior.

2.4.2. Main psychosocial issues of microplastics identified from the selected articles

Table 2.2 shows the objectives, main topics and psychosocial aspects specifically tackled in the articles analyzed. As expected from the network map in Figure 2.2, regulation and governance –actually the difficulty of governance- have been the direct focus of many articles. Lam et al. (2018) put the focus on consumers' individual responsibility, while Mitrano and Wohlleben (2020) studied how public demands determine microplastics governance approaches in different countries. Landon-Lane (2018) and Eriksen et al. (2018) explored the important role of corporations in microplastics governance. Abalansa et al. (2020) pointed at different economic sectors to be involved in the search of solutions.

More directly related with psychosocial issues, the association between perception and risk perception was the main interest of Soares et al. (2020) and Usman et al. (2020). Since microplastics are invisible, the global problem is not seen and the risk is not perceived (Soares et al., 2020). These authors think that the objective transmission of knowledge is difficult precisely because the threat is unseen. As commented by Kramm and Volker (2018), stakeholders and consumers may not perceive the risk of MP emission derived from their practices, so they do not feel responsible of MP pollution. In her article about the new global risk posed by marine microplastics, Katsnelson (2015) commented that the public concern starts when microplastics are made visible. Usman et al. (2020) showed in their review that, while the majority of studies tackle environmental risks, consumers are more concerned by the microplastics present in food whose risk is more easily perceived.

Several authors explored barriers to behavior change regarding microplastics. Dauvergne (2018) pointed at distancing the emitters (consumers, corporations) and the problem (plastic waste and microplastics), exporting waste to third countries, as a common practice. It is a way to put the problem out of sight and shift the responsibility of proper disposal elsewhere. The same strategy was mentioned by Kramm and Volker (2018) -although they were more interested in risk perception- in relation to different groups of interest: corporations, consumers and policy-makers have different risk perception of microplastics and put the responsibility of reducing them on the shoulders of other groups. Angnunavuri et al. (2020) investigated barriers to the change of consumer's behavior in developing countries, with a focus in Africa (Table 2.2). Related with waste exports, Stoett and Omrow (2021) pointed at the legal and illegal movements of large waste quantities between countries as global impediments to eco-friendly attitudes. The business associated with waste imports encompasses what the authors call eco-violence, hampering the efforts of safe recycling behavior in both donor and recipient countries.

The role of media in the transmission of scientific knowledge to the general public was the focus of several articles. Several articles commented the role of media in the poor transmission of scientific knowledge about microplastics (Schnurr et al., 2018), doing it in not always balanced ways that contribute to exaggerate the perception of associated risks (Catarino et al., 2021; Usman et al., 2020; Volker et al.,

2020) or diminishing the current knowledge in ecological risks while emphasizing preoccupation for microplastics in food (Rist et al., 2018).

Mitigation of microplastics employing psychosocial tools for consumers' behavior change has been the main subject of several reviews (Giri, 2021; Lohr et al., 2017; Pahl & Wyles, 2017; SAPEA, 2019). Solutions would include campaigns against plastics (Penca, 2018) and glitter (Yurtsever, 2019), and for the use of recycled products (Prata et al., 2019).

Table 2.2. Summary of the articles retained in this study. MP: microplastics; SDG, Sustainable Development Goals. NRef: number of references cited in the article. Key psychosocial factors considered in the article are marked in bold italics.

Reference	Objective	Main topic	Type of study	NRef	Conclusions relevant for psychosocial interventions
Abalansa et al. 2020	Assess causes and effects of marine MP pollution	Engagement	Review	179	***Engagement*** measures such as technology, cleaning, ***awareness creation***, enacting policies and regulations will reduce upstream pressures like littering and poor recycling.
Angnunavuri et al 2020	Review the causes and effects of MP in the African environment	Knowledge & consumer behaviour	Review	192	***Little knowledge and awareness of microplastics*** determines ***consumer behaviour*** in developing countries, especially in Africa. International cooperation in research and intervention policies is needed.
Catarino et al. 2021	Analyse the relation between MP risk evidences & perception	Risk perception	Review	89	The public ***perceives microplastics as a serious environmental and health risk***, which is not entirely supported by scientific evidence, but has ***motivated*** political action.
Dauvergne 2018	Analysis of plastic pollution governance failure	Governance	Review	110	Corporations advocate for self-regulation and consumer responsibility. ***Distancing of plastic waste*** (exporting waste) is still seen as an option.
Eriksen et al. 2018	Discuss stakeholder costs and benefits of MP mitigation in a social justice context	Stakeholder engagement	Perspective	119	Scientific observations of MP pollution will press policymakers to regulate industry. This can only be promoted convincing stakeholders, from ***knowledge and sense of justice***, to ***engage in the prevention*** of primary MP production, integrating environmental and social justice in plastic production.
Giri 2021	Analyse contemporary strategies to improve river water quality	Awareness, stakeholder engagement	Review	>200	***Lack of environmental awareness*** and ***resistance to change*** are highlighted are impediments to a better water quality, especially in developing countries. Communication, environmental education, training, and ***awareness*** will improve waste management and environmental ethics.
Katsnelson 2015	Start tackling MP in a rigorous way	MP as a global risk	Perspective	21	Marine microplastics crisis, perceived as less problematic than global problems like coastal erosion or CO_2 emissions - only ***when plastics are made visible people are concerned***.
Kramm & Volker 2018	Understanding social-ecological implications of MP	Risk perception	Review	71	MP management and policy decisions informed from ***risk perception*** by different interest groups. ***Responsibilities are often shifted elsewhere.*** Some voices do not regard plastics as the source of the problem but rather their improper disposal; other voices emphasize the design of the plastic material, and yet others target ***consumer behavior***.
Lam et al. 2018	Explore strategies to develop plastic legislation	Prevention & governance	Review	107	Consumers play a major role in the generation of plastic waste. Thus, responsible waste handling is the ***social awareness and behaviour*** to accomplish an effective recycling scheme.
Landon-	Potential of corporate	Governance	Review	49	Corporations are responsible to stop MP emissions, following sustainable plastics industry

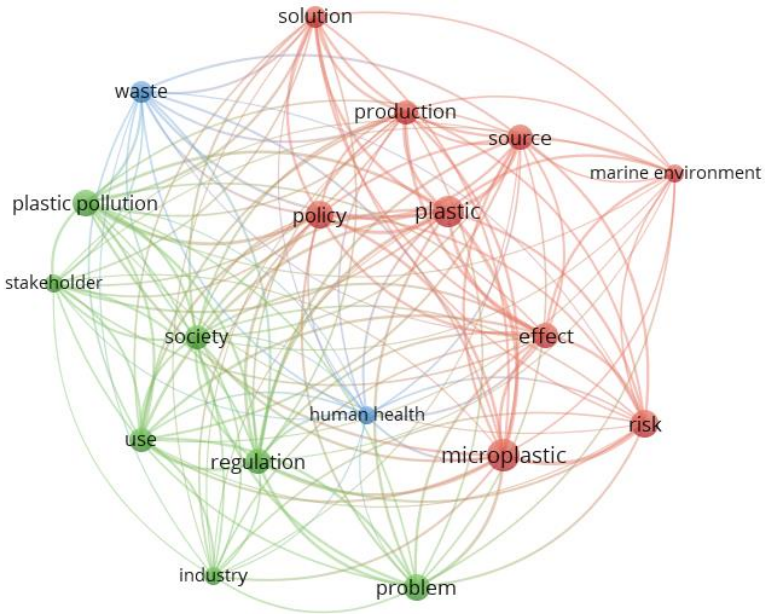
Lane 2018	social responsibility to manage plastic use				principles. Biodegradable plastics recommended to prevent MP. ***Corporate social responsibility as corporate behaviour beyond regulation, from environmental awareness*.**
Lohr et al 2017	Possible interventions against marine plastic & MP	Prevention, SDG perspective	Perspective	87	Reduction of marine litter & MP requires ***changing consumer behaviour*** about primary & secondary MP. Sustainable Development Goals 6.3, 11.6, 14 are involved.
Mitrano & Wohlleben 2020	Discussing restrictions to MP	Regulation & public demands	Perspective	71	***Policy development and industrial practices are affected by consumer voice and behaviour***. From concern to action, activism drive real (or perceived) change. ***Differences between countries*** in regulations, and for public demands. Microplastic hazards are uncertain, and actions are not similarly prioritized by all actors.
Pahl & Wyles 2017	To guide future social research to mitigate environmental MP.	Psychosocial tools for mitigation	Review	51	Qualitative methods recommended to explore new areas of research. Quantitative approaches to test the ***role of perceived risk, values, social norms for behaviour*.** Experimental quantitative approaches to study cause–effect relations. ***Communications and interventions should be based on scientific insights into human thought and behaviour and evaluated systematically*.**
Penca 2018	Explore EU's Plastics Strategy environmental consequences	Prevention from policies & campaigns - EU focus	Perspective	15	Political strategy in the EU to change plastics treatment to circular economy. MP are considered. Includes ban to MP & ***campaigns for consumers to refuse plastic products***.
Prata et al. 2019	Discuss how to improve plastics management	Prevention – consumer behaviour change	Review	152	Circular economy is necessary, but needs ***consumers to change their behaviour*** in order to use recycled products and to discard properly used ones
SAPEA 2019	EU Academies advice on MP	MP and the society: psychosocial aspects	Perspective & Review	>200	Proliferation of opinion misrepresenting scientific facts, ***limited public knowledge and risk perception*** of MP, may be ***perceived as temporally or spatially distant***, unnatural & unnecessary. Keys to ***change attitude*** towards MP: ***Concern, perceived behavioural control, identity, values, attitudes, emotions and personal and social norms, knowledge, and awareness*.**
Schnurr et al. 2018	Discuss actions to reduce plastic	Knowledge & awareness	Review	>200	***Lack of public knowledge, education & awareness*** - poor transmission of scientific results. Arguments against plastic bans - environmental impacts of paper & cloth bags- overlooked.
Soares et al. 2020	Discuss transmission of scientific information about MP	Risk perception	Perspective	103	Difficult ***transmission of knowledge*** because MP are invisible, thus ***risk is not perceived***: an invisible global problem without a global solution yet.
Stoett & Omrow	Explore agential & structural violence in	Recycling impediment,	Perspective	69	The global movement for safer ***recycling behaviour*** is hampered by increased illegal waste exports / imports in some countries. Conceptualizing the pollution of the commons (oceans,

2021	transboundary movements of waste	global governance			lakes, air) as a form of transnational ecoviolence may help us formulate a ***clearer understanding of our concerns***.
Usman et al 2020	Compare knowledge of MP in marine environment vs food	Risk perception	Review	145	Risk in scientific papers is often focused on environmental risks. No current policy to monitor and regulate microplastics in commercial foods meant for human consumption, whose ***risk is perceived higher*** by people.
Volker et al. 2020	Investigate how MP risk is treated in science and media	Risk outreach	Review	74	Most scientific studies frame MP risks as hypothetical or uncertain, while most media articles imply that risks of MP exist, and harmful consequences are highly probable. ***Wrong transmission of scientific knowledge increases public risk perception*.**
Yurtsever 2019	Explore MP risk derived from glitters	Awareness	Review	95	Glitter as an ***aesthetic need and psychologically fun*** - unconscious use by unaware consumers. Most people have ***no knowledge or awareness*** about the glitters' impact on the environment.

2.4.3. Landscape of topics in reviews and perspective articles

Applying a threshold of 4 occurrences, the network created from the 18 relevant terms extracted from the 818 words identified in texts, keywords and abstracts of these papers showed three clusters (Figure 2.2). The central terms were "policy" (close to "plastic", "production" and "solution", and connected with "microplastic", "effect", "risk" and "source" in the red cluster), "human health" (together with "waste" in the blue cluster), and "society" and "regulation" (together with "problem", "use of plastics", "stakeholder", "plastic pollution" and "industry"). This map of clusters summarizes the essential of this collection of articles. Policy, society, regulation and human health are central while the word "consumer" or psychosocial terms do not appear. The network could read like this: "*Policies about plastic production and sources will offer solutions to the risk of microplastics effects in the marine environment,"* (red cluster), *"and of waste in human health…"* (blue cluster; solution is close to waste), *"…while plastic pollution derived from the use (of plastic) by stakeholders is a societal problem to be tackled from industry regulation"* (green cluster). The picture depicted here shows a top-down approach to the risks of microplastics and plastic pollution, led by policies and regulations rather than by individual awareness or behavior. Industry regulation would solve the problem of plastic pollution, and policies about plastic production would solve microplastics risks in the marine environment.

Figure 2.2. Network map created from relevant terms occurring at least four times in titles, keywords, and abstracts of the selected articles, using VOSviewer software. Terms are connected by links that represent their co-occurrence in articles and texts. Links' width is proportional to their strength.

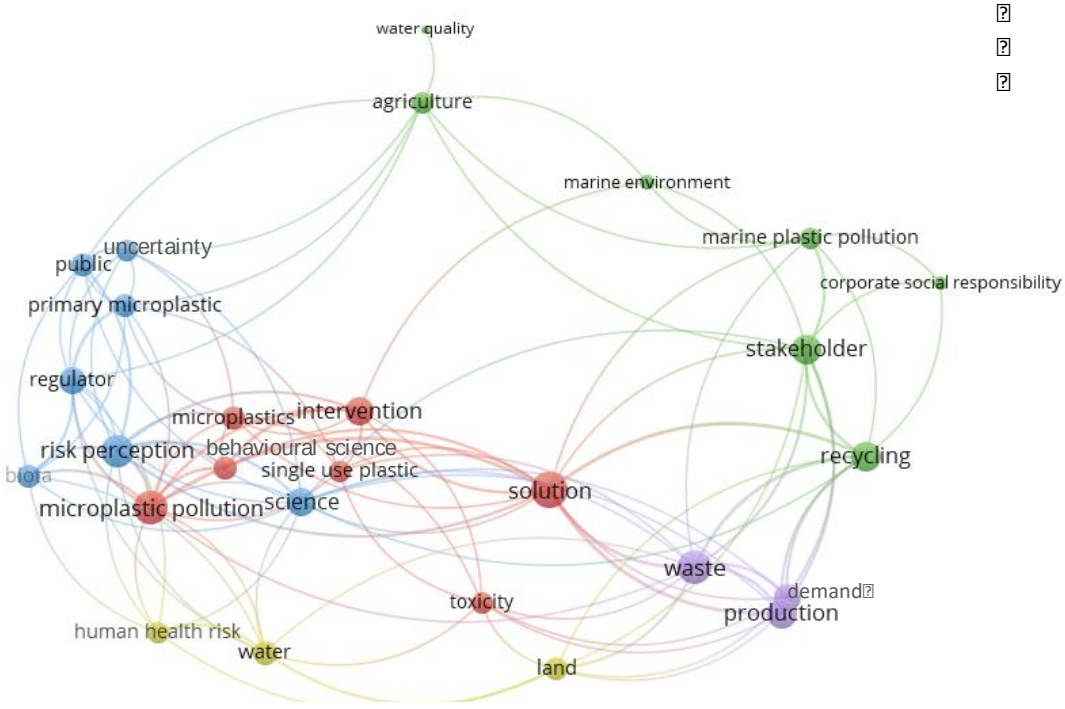


Applying a threshold of 3 occurrences psychosocial terms appear in three of the five clusters (Figure 2.3): "behavioural sciences" as a central word in the red cluster with microplastics, intervention and single use plastic; "corporate social responsibility" and "recycling behavior" in the green cluster together with stakeholder and words related with the environment like agriculture (a source of microplastics), water quality and marine environment; "risk perception" and "uncertainty" together

with public, regulator and primary microplastics in the blue cluster. In addition, the term "(consumer) demand" – shared by psychology and economy- appears in the purple cluster with production and waste. Summarizing, in the analyzed articles important psychosocial issues related with stakeholders (green cluster) are those related with producer responsibility and consumer behavior (specifically recycling). The novelty of the threat is reflected in the blue cluster where risk perception linked to uncertainty, in the same cluster with science. The red cluster represents solutions, where behavioural sciences are central to design interventions against single-use plastics that in the articles examined are an important source of microplastic pollution. In the purple cluster it seems that consumer demand would determine production (of plastic and microplastics) thus be an ultimate cause of waste (Figure 2.3). Finally, in the yellowish cluster human health risk would be associated to both land and water, important recipients of plastics and microplastics.

In the two networks plastics and plastic pollution appear in addition to microplastics. Indeed, microplastics are plastic, and the spontaneous production of microplastics from larger plastics, often of single use, has been reflected in the network map of Figure 3.

Figure 2.3. Network map built from relevant terms occurring at least three times in titles, keywords, and abstracts of the selected articles. VOSviewer software was employed.



2.4.4. Emerging psychosocial issues in the microplastics crisis

The analysis of relevant terms with at least two occurrences showed different foci in reviews and in perspective articles, with 38 and 18 terms respectively (Table 2.3). Ten psychosocial terms not overlapping in reviews and perspectives were

directly identified in the list: awareness, corporate social responsibility, uncertainty, microplastics perception, risk perception, consumption, recycling (reviews); knowledge, understanding, responsible consumption (perspectives). The last term implies that "consumption" was qualified as "responsible" as a way of mitigation; thus, we classified primarily that term in the category of Mitigation, and secondarily as Psychosocial since the context was mitigation of the problem. Similarly, we classified "recycling" primarily in Mitigation for its context in the articles; recycling can be either an individual behavior and/or a corporate, national or regional strategy to mitigate plastic waste. The rest of terms were classified in a single category.

The five most relevant terms in perspective articles (28% of these articles) described problems (microplastics, plastic pollution), a mitigation strategy (circular economy), waste as microplastics source and society as the main actor. The rest of relevant terms found in perspective articles were very far from these five (Table 2.3). In review articles, the 28% most relevant articles (first 10 in the rank) included: a) three psychosocial terms (corporate social responsibility, uncertainty, consumption), b) two actors (public, consumers of plastic), c) two policy measures (bans and levies to plastic products), d) three terms related with policy (levy, bans, policy effectiveness) and e) one problem (marine plastic pollution) as one source (landfills) (Table 3). It is worth noting that in the category of "Actors" the terms were principally related to individual consumers (Public, Consumers…), science and politics (Regulators), but no one was referred to the industry.

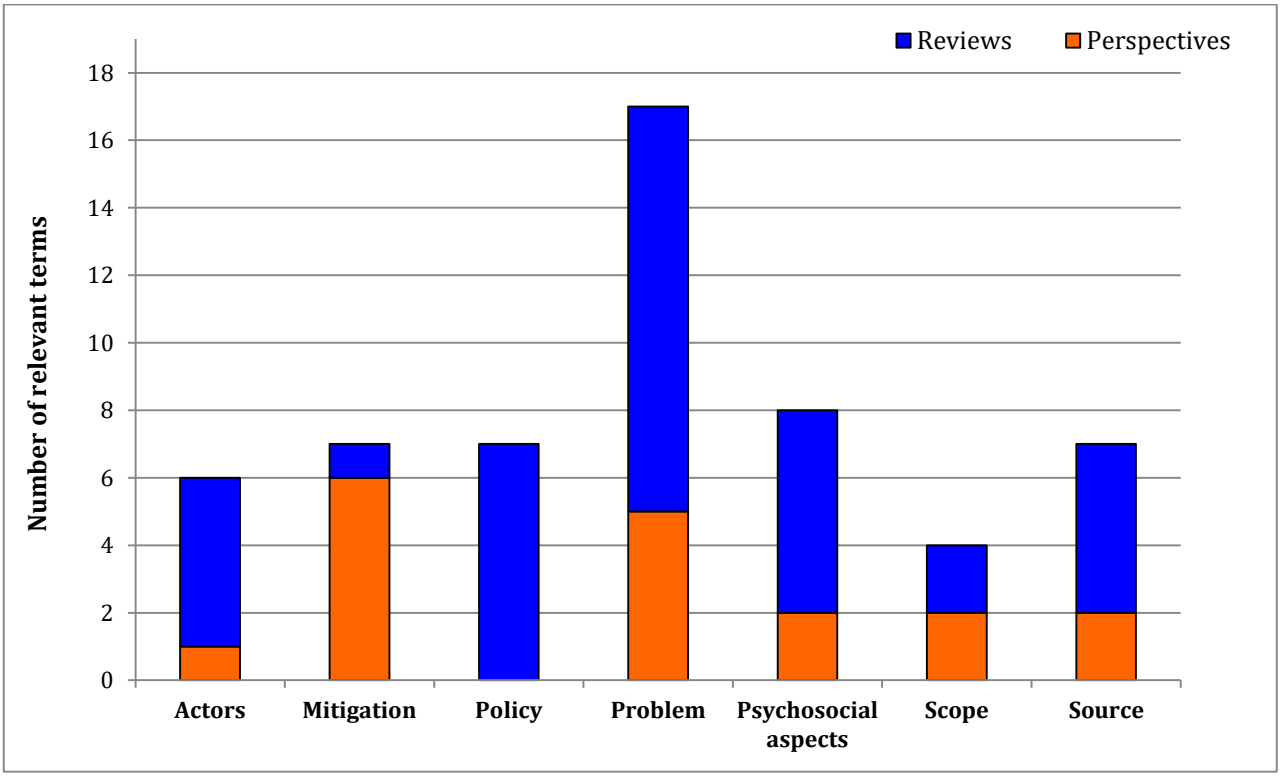
Few terms were shared in the two lists: plastic pollution, marine pollution, risk, negative (= adverse) effect, consumption (with the adjective "responsible" in perspective articles), and waste (Table 2.3). Plastic pollution and global marine pollution were in the first quartile of the two lists; but some of these terms were not formulated identically nor occupied similar positions in the rank. For example, the term "negative effects" (of microplastics) was qualified by the adjective "possible" only in the list of perspective articles; the term "waste" was second with a high relevance (3.44) in the list of perspective articles, and 25th with only 0.98 relevance score in the list produced from review articles. Many terms containing the word "risk" appeared in the list derived from reviews, but only one term appeared in perspective articles list (Table 3). Science (here classified as an actor, as scientific knowledge and its transmission is fundamental in the microplastics crisis) appeared only in the word list of the reviews.

Table 2.3. Relevance of terms (minimum 2 occurrences) selected from abstracts, keywords and titles of the perspectives and review articles analyzed.

PERSPECTIVES			REVIEWS		
Term	Relevance	Category	Term	Relevance	Category
Microplastics	3.8	Problem	Corporate social responsibility	2.01	Psychosocial
Waste	3.44	Source	Public	1.55	Actor
Plastic pollution	3.31	Problem	Uncertainty	1.5	Psychosocial
Circular economy	3.18	Mitigation	Levy	1.46	Policy
Society	3.16	Actor	Ban	1.46	Policy
Environment	0.15	Scope	Policy effectiveness	1.46	Policy
Current knowledge	0.12	Psychosocial	Consumer (of) plastic product	1.41	Actor
Effective action	0.12	Mitigation	Marine plastic pollution	1.39	Problem
Global marine pollution	0.12	Problem	Landfill	1.3	Source
(Societal) initiative	0.12	Mitigation	Human consumption	1.3	Psychosocial
Possible adverse effect	0.12	Problem	Ocean	1.28	Scope
Possible intervention	0.12	Mitigation	Microplastic risk	1.26	Problem
Profound understanding	0.12	Psychosocial	Political action	1.19	Policy
Responsible consumption	0.12	Mitigation, psychosocial	Risk assessment	1.19	Policy
Risk	0.12	Problem	Consumer	1.14	Actor
Solid basis (of evidence)	0.12	Mitigation	Microplastic pollution	1.14	Problem
Source	0.12	Source	Pressure	1.11	Problem
Worldwide	0.12	Scope	Recycling	1.07	Mitigation, psychosocial
			Public risk perception	1.07	Psychosocial
			Exposure	1.05	Problem
			Science	1.02	Actor
			Perception	1.02	Psychosocial
			Strategy	1	Policy
			Risk	0.99	Problem
			Waste	0.98	Source
			Complexity	0.96	Problem
			Legislation	0.8	Policy
			Land	0.79	Source
			Regulator	0.73	Actor
			Awareness	0.72	Psychosocial
			Single use plastic	0.71	Problem
			Water quality	0.61	Problem
			Human activity	0.6	Source
			Food	0.48	Scope
			Agriculture	0.48	Source
			Plastic pollution	0.48	Problem
			Human health risk	0.45	Problem
			Negative effect	0.29	Problem

As expected from the results shown in Table 2.3, the two types of studies differed significantly in the distribution of terms in the seven categories considered (Actors, Mitigation tools, Policy, Problems, Psychosocial issues, Scope and Sources): $\chi^2_{(7,2)} = 14.06$ with $p = .03$; Fisher's exact test with $p = .026 < .05$, adequate Cramer's V = 0.448. The category Problems contained the majority of relevant terms in review articles (31.6% of the terms) and the category Policy was the second one (Figure 2.4). In contrast, terms related with Mitigation were the most abundant in perspective articles (33.3%). Thus, reviews were focused on risks and policies, while perspectives would focus principally on solutions not so much based on regulations. Although Penca (2018) and Mitrano and Wollehben (2020) considered policies and regulations in their articles (Table 2.2), terms categorized as Policy did not reach enough relevance to appear in the list generated from perspective articles (Figure 4). Some terms included in the category of Mitigation in the list of perspective articles were quite ambiguous, such as societal initiative and possible intervention, but the highly relevant circular economy, individual responsible consumption and solid basis (of evidence) as a requirement for mitigation actions pointed at quite clear mitigation strategies.

Figure 2.4. Frequency of relevant terms in different categories for reviews and perspective articles found in the present study.



Focusing on terms related with psychosocial issues, the list produced from perspective articles had (current) knowledge and (profound) understanding (Table 2.3). In reviews, relevant terms were corporate social responsibility, the first word in the list (Table 2.3), then uncertainty (that would represent the opposite to the concept of profound understanding), consumption, risk perception, knowledge and awareness. Individual responsible consumption appeared in perspectives' instead of the corporate

responsibility of the reviews' list, but in the reviews the word "consumer" appeared twice, implying their role as actors in the microplastics crisis.

Summarizing, real research reflected in the reviews has focused on individual and corporate responsibility about microplastics, while what seems to be needed from the relevant terms in perspective articles is new, efficient initiatives based on solid bases of understanding. The main relevant term that appeared in perspectives but not in review articles was circular economy (Table 2.3). Individual responsible consumption would be an emerging solution, and the need of a deeper understanding and solid bases for action against microplastics were also emphasized. While the whole society is the actor that emerges from perspectives, emphasizing the multifaceted aspects of the microplastics crisis, reviews tend to focus on more specific sectors, like consumers or regulators.

2.5. Discussion

The first observation in this review was the small number of articles retained in the literature search. Perhaps for the novelty of this emerging contaminant, there is still relatively little research about the psychosocial issues involved directly or indirectly in the raise of microplastics. In line with the EU Academies (SAPEA, 2019), more efforts in this field of investigation are necessary. The synthesis articles analyzed in this study propose the use of psychosocial research and methodology to mitigate current microplastics crisis in different ways, principally changing consumer's behavior (perspectives) and enhancing corporate social responsibility (reviews). From its relevant position in perspectives but not in reviews, the societal change towards circular economy is an emerging issue that would need much attention from social psychologists in the upcoming years.

Cutting down plastic and microplastic pollution is, from our study, an emerging responsibility of all the society. From the results of our study, the responsibility of corporations and consumers, and their behavior (as individuals or corporations), are key to understand why in this moment microplastics governance is failing. The focus of most reviews has been the behavior of individual consumers and its top-down regulation, that is, policies that prevent the use of plastics and microplastics (e.g., Lam et al., 2018; Penca, 2018). Lam et al. (2018) claimed for social awareness and pro-environmental behavior to be able to accomplish recycling schemes needed to prevent microplastics. The inclusion of circular economy as main emerging solution changes a little bit the focus. If circular economy is the goal, we should investigate the perspectives about microplastics of companies, politicians and resource managers from a psychosocial point of view, to involve all actors in the common goal of fighting this emerging global threat. Indeed, individual responsible behavior is always needed, since individual actions like littering, dumping and bad recycling contribute crucially to the enormous level of plastic pollution. However, plastic is also used by other than individual consumers. There are many industrial uses of plastic, and the industry has also its own drivers, like the oil industry that produces its raw material. Investigating the point of view of the industry as a producer and consumer of plastic is still a big research gap.

The vision and corporate behavior of companies is indeed essential in circular economy. Abandoning plastic for more sustainable options is a challenge that will need not only a green organizational culture (Lasrado & Zakaria, 2020), also the firms have to be convinced of green image to provide economic benefits at the long term (Xie et al., 2019). Taking into account human behavior in the process of adaptation of

companies to circular economy, like leadership styles, is a gap identified by Pieroni et al. (2019). Landon-Lane (2018) proposes to increase environmental awareness of corporations to harness corporate social responsibility; this way, plastics industry will follow sustainability principles and innovate in products to stop microplastics emissions. Eriksen et al. (2018) emphasize the need for scaling zero-waste strategies and convince corporations and other stakeholders to align on equitable end-of-life of plastic, including costs of environmental and social justice in its final cost. Abalansa et al. (2020) claimed for the involvement of all types of stakeholders, from different economic sectors (agriculture, fishing, construction, transport), in global solutions to stop MP emissions including creation of awareness and engagement in environmental protection.

The perspective of journalists is also important. Today, media are focused on the plastics problem that seems to be more tangible and manageable than other important environmental issues, like ocean acidification for example (Tiller et al., 2019). Despite the facts and figures described in the introduction, there are still doubts about the real magnitude of the threat - as it is normal in a so novel and recent research subject. For authors like Volker et al. (2020), media "translate" scientific knowledge about microplastics exaggerating the risk. Although scientists frame microplastics risks as potential or hypothetical, media present risks as certain and harmful consequences as highly probable. Moreover, media tend to cover scientific articles about microplastics in seafood more frequently than studies about microplastics in other environmental compartments, so emphasizing the threat for humans (Usman et al., 2020; Catarino et al., 2021). Media coverage is clearly biased because there are more studies about environmental risk than about risk associated to human consumption of microplastics via food (Usman et al., 2020). Volker et al. (2020) concluded that the public debate should be informed by unbiased scientific knowledge to prevent dramatization of certain issues while overlooking other important ones (for example microplastics in plankton, which is the base of the ocean trophic chain and provides oxygen to the atmosphere). In this sense, Schnurr et al. (2018) point at a poor transmission of current scientific knowledge to explain the lack of public knowledge, awareness, and education about microplastics. Catarino et al. (2021) think that, although science has not reached a consensus on the toxicity of microplastics for biota and humans yet, we should adopt precautionary measures to combat microplastic pollution. For these authors, the high level of public awareness offers a good opportunity for a transformation toward a more sustainable economy (Catarino et al., 2021). Despite the doubtless role of media in the transmission of scientific knowledge, we have not found specific studies investigating the perspective of journalists about this subject. Investigating current coverage of plastic pollution in UK news sites, Keller and Wyles (2021) found very emotive topics (for example entangled charismatic marine animals) but lack of focus on consumer responsibility, that as we have seen here is crucial to stop microplastics pollution. On the other hand, the perspective and priorities of scientists should be considered too. Usman et al. (2020) highlighted a discrepancy between the majority of current studies on microplastics that have an ecological perspective, and the scarcity of studies about microplastics content in food and seafood, that are very important for most consumers.

Solutions of psychosocial nature proposed to mitigate microplastics emissions are diverse. Pahl and Wyles (2017) made a complete review of social research methodologies (qualitative, quantitative and experimental quantitative) to study psychological determinants of pro-environmental behavior that could mitigate

microplastics. They highlight, amongst others, perceived risk, values and social norms. They also emphasize the need of basing both communication and interventions on scientific insights in human behavior and thought. The European Academies (SAPEA, 2019) compiled their work and others about pro-environmental behavior and pointed at key psychosocial traits that are involved in microplastics mitigation, like knowledge, concern, perceived behavioral control and personal and social norms, also values, attitudes, emotions and identity. From the perspective of Sustainable Development Goals (SDG, UN 2021), Lohr et al. (2017) recognize that the reduction of marine litter including MP, which is SDG#14, needs a change of consumers' and stakeholders' behavior. Knowledge, leadership and skills to deal with the problem can be stimulated at all levels to raise global awareness and increase action and interaction between all stakeholders (Lohr et al., 2017). For Giri (2021), collaboration with and between local stakeholders is essential to achieve water sanitation agenda developed by UN for 2030 specifically in developing countries, and raising environmental awareness to engage stakeholders is fundamental there. Penca (2018) reflects on how to implement current EU strategies to mitigate microplastics, and emphasizes the need of changing consumer's behavior, proposing campaigns against the use of plastics. Those campaigns should be designed following solid psychosocial principles. Prata et al. (2019) also pointed at consumer's behavior changes for making circular economy real, claiming for interventions in order to increase the acceptance and use of recycled products.

Most solutions proposed so far are related with waste disposal and treatment, with the reduction of plastic use, and with the consumption of microbead-free products. However, a source of microplastics not sufficiently studied yet is microfibers from textiles and clothes. Although aware consumers would buy devices to retain microfibers in washing machines (Herweyers et al., 2020), a sustainable clothing behavior would require buying more expensive natural textiles instead of clothes of cheap artificial materials. People involved in the fashion industry recognize that a radical change in consumption patterns may be the only way forward; even though, they would require a deeper knowledge about scientific facts and figures to be convinced to undertake such a change (Yan et al., 2020). Related with fashion, Yurtsever (2019) alerted about the potential risks of apparently harmless glitter, that produces serious microplastics pollution, because of its wide use and psychological benefits as an aesthetic need. Consumers should be informed of the risk.

Last but not least, this is a global crisis and solutions must be indeed local, but without missing the global perspective. Not all the countries are equal. Mitrano and Wohlleben (2020) report significant differences between countries regarding regulations and public demands; they remark that consumers' behavior is crucial to the development of environmental policies, and also influences industrial practices. Therefore, country culture would be a factor to take into account to understand psychosocial determinants of microplastics mitigation. In this sense, Angnunavuri et al. (2020) point at the lack of knowledge and awareness about the MP content in different products as a barrier to consumer's behavior change in developing countries. For these authors, plastic mismanagement is partially driven by inappropriate social behaviours, poor political decisions, the lack of financing and investment mechanisms and the absence of producer-consumer responsibilities, all together constraining the management of waste plastics in Africa. At consumer level they suggest, amongst other practical solutions, to increasing the information about MP in the package and labels of commercial products. Dauvergne (2018) points at the need of local

regulation of industries and, at the same time, at the establishment of international treaties to support and strengthen the local reforms. International social justice regarding plastic and microplastics should be a priority in the upcoming years. Lau et al. (2020) estimated an increase of net waste export from high-income to lower-middle income countries of around 1.1 Mt/year by 2040, which is really enormous. Waste imports hamper the capacity of developing countries to manage safely their own waste (e.g., Velis, 2015), especially small particles like microplastics that need special treatments in wastewater plants (Hamidian et al., 2021). All countries being interconnected, the appealing concept of circular economy to approach zero waste is today far from realizable in entire continents like Africa, due to systemic failures like low technological capacity for the production of innovative materials, or informal recycling reality (Velis, 2018). The global perspective of Sustainable Development Goals adopted by Lohr et al. (2017) is one of the ways to consider in future psychosocial studies about solutions to the microplastics crisis.

2.5.1. *Conclusions*

In conclusion, the current landscape of review and perspective articles suggests a mismatch between current psychosocial research on microplastics and emerging directions of possible solutions. While current research is focused on individual drivers of pollution, there is no much research about efficient solutions to change societal habits. Research efforts are now centered in corporate social responsibility, but circular economy is identified as the future framework to cut down the microplastics crisis. The role of the media to make people aware of the problem is also highlighted.

2.5.2. *Recommendations of psychosocial nature*

Since uncertainty and the need of solid basis for interventions have been identified as relevant terms in our study, qualitative, quantitative and experimental quantitative researches are needed to explore current public awareness and to design interventions against microplastics emissions.

Corporations should engage in sustainable practices –like not exporting plastic waste to third countries, using less plastic packaging, recycling- and invest in technological innovations to abandon plastics and primary microplastics. Psychosocial tools to help companies in these green innovation changes are of priority.

Consumers should move towards the consumption of products without primary microplastics.

Against secondary microplastics, consumers should adopt R imperatives as recycling and especially reusing. Accepting alternative materials like bioplastics can be envisaged, as long as they are truly environmentally friendly throughout their whole life cycle, including end-of-life disposal. The environmental impact of new materials must be carefully assessed before production.

Since microplastics are invisible and their risk is not easily perceived, a sound, understandable, reliable transmission of current scientific knowledge is sought for the sake of informed and objective societal awareness of microplastics and their environmental health risks. The same principles should inform policies and regulations aimed at the prevention of primary and secondary microplastics.

CHAPTER 3

STUDY 2: ON THE NEED OF PUBLIC KNOWLEDGE TO FACE MICROPLASTICS

Publication:

Garcia-Vazquez, E., & Garcia-Ael, C. (2021). The invisible enemy. Public knowledge of microplastics is needed to face the current microplastics crisis. *Sustainable Production and Consumption, 28*, 1076–1089. https://doi.org/10.1016/j.spc.2021.07.032.

3.1. Abstract

Microplastics are emerging pollutants that threaten marine resources globally today. Being invisible to the human eye, their public perception and risk perception depend upon the information passed on citizens. Psychosocial theory postulates the importance of knowledge, attitude, and perceived control to undertake pro-environmental behaviors. In this review we have analyzed relevant literature about psychosocial determinants of microplastics emissions and found new directions where research should be focused. Enlarging the geographical scope of present studies to include African countries, undertaking intercultural studies to determine the scale of interventions for public sensitization about the problem, studying the perspective of the industry, politicians and journalists, and improving the way of communicating scientific knowledge about this new threat are highly recommended.

3.2. Introduction

3.2.1. The global microplastics crisis

The planet is today in the middle of what has been called the microplastics crisis. The term, employed by scientists (Katsnelson, 2015) and politicians, describes the raise of huge amounts of small plastic particles that form a part of the Plastiphere in the Anthropocene era. The ultimate fate of plastics and microplastics is the ocean (Thompson et al., 2004) that could be seen like an enormous landfill where much of the plastic waste arrives at the end. Just as an example, in the EU between 75 000 and 300 000 tons of microplastics are released into the environment each year (European Commission, 2018). After entering the ocean, microplastics become part of the beaches' sand, are suspended in the water column, eaten by marine animals, deposited on the algae, or forming already a part of the sediments in the deepest abyssal plains (Woodall et al., 2014; Auta et al., 2017). COVID-19 has worsened the problem in the last year for the increase of plastic waste that arrives in the ocean derived from protective equipment and hygienic masks (e.g., Patricio Silva et al., 2021).

Andrady (2011) and Law and Thompson (2014) summarized the causes of the increase of microplastics in the ocean. Microplastics are typically particles smaller than 5 mm that can either be directly produced of this size (primary microplastics) or be the product of degradation of larger plastics (secondary microplastics). Primary microplastics are micro- or nanobeads that are added to many products employed in personal care (e.g., whitening toothpaste, scrub cosmetics) and in the industry (e.g., abrasive cleaning treatments). Secondary microplastics are mainly produced in situ in the ocean by breakage of marine plastic litter for the effect of sun radiation and the physical action of ways and currents. They can also come from the land (Wagner & Lambert, 2017), as microplastics when they escape waste treatment, since for their small size wastewater treatment plants cannot retain 100% of the microplastics; many secondary microplastics are fibers produced during clothes washing, because many washing machines do not retain microfibers efficiently (Andrady, 2011; Law & Thompsons, 2014).

The amount of plastic pollution and microplastics seems to vary among regions in the planet, depending on the societal consumption habits and the facilities for waste disposal and treatment in the continental areas nearby. Microplastics are especially abundant near big urban settlements, in estuaries and around river mouths – because rivers collect and transport plastics and microplastics from all basins upstream (Lebreton et al., 2017). At a large scale, van Wijnen et al. (2019) showed

that East Asia and Pacific waters receive the largest microplastics import from rivers and the land, followed at a distance by OECD countries (Europe and North America), then closely African waters (except Middle East and North Africa). Expectations are that if business follows as usual or in an equal world scenario, Africa will be the second continent by 2050, only surpassed by OECD countries in a hypothetical scenario of 90% solid waste collected and adequately treated worldwide (van Wijnen et al., 2019). On the other hand, microplastics exports of Middle East and North Africa, and of Eastern and Central Asia, are today and are expected to be lower by 2050 (van Wijnen et al., 2019). Objective data and projections of microplastics pollution are accompanied by the interest of scientists, scientific publications about microplastics being correlated with the plastic waste generation per country (Klingelhöfer et al., 2020). Many of the big rivers in the planet are in Africa, and recent investigation has shown a relatively large number of publications about microplastics in waters of South Africa and the Gulf of Guinea (Alimi et. al., 2021). However, this cannot be applied to socioeconomic studies, where countries like Portugal, Chile, Ireland, Norway and Slovenia lead the rank, irrespective of their relative microplastics pollution and their studies about environmental quantities and impacts of microplastics (Klingelhöfer et al., 2020). It seems that the social aspects related with microplastics are less covered than the environmental ones.

The difference between primary and secondary microplastics is not trivial because the actions required to prevent and mitigate pollution are essentially different. The ultimate cause of the release of primary microplastics in the environment is the consumption of products with such microplastics, while the causes of secondary microplastics are related with failures to apply R-imperatives in plastic consumption and waste behavior. These 10R options, initiated by consumers and companies, prevent waste, and retain value through the entire life cycle of a product (plastic in this case): Refuse (to buy), Reduce, Reuse/Resell, Repair, Refurbish, Re-manufacture, Re-purpose (or Rethink = find a new use of old components), Recycle, Recover, Re-mine (Reike et al., 2018). In other words, primary microplastics can be prevented just not consuming products that contain such microplastics. In contrast, secondary microplastics are much more complex because the sources are varied, as the uses and disposal of plastic are in current societies.

Why should we worry about behaviors that promote microplastics pollution directly or indirectly? The microplastics crisis looks like a serious problem for the marine pollution it represents, but in addition it is intertwined with other global problems like climate change (Shen et al., 2020), through greenhouse gas emissions along the plastics and microplastics life cycle (Hu et al., 2019). Moreover, marine biodiversity is at risk because plastic particles, when accumulated at a certain level, cause harms to organisms all across the trophic web from plankton to top predators (e.g., de Sá et al., 2018). But microplastics emissions do not come without a toll for the emitters. Produced by humans, ironically microplastics return to humans –like a sort of bad karma– via air, water, and seafood. Humans eat algae, shellfish and fish that contain microplastics. Although still not well know because the consequences of ingestion of microplastics via seafood have been little studied, there is a suspect of harmful effects on human health (Smith et al., 2018). Microplastics acquired via breath can produce lung cancer (Prata, 2018), not only by physical damage but also because microplastics release accompanying toxic molecules that cause chemical and biochemical damage in different organs and even produce neurological effects (Campanale et al., 2020). Thus, microplastics could be considered a menace not only

for the environment but also for human health. Looking for solutions is urgent because, even if the studies are still scarce and the global impact of microplastics in the planet has not been accurately estimated yet (Hale et al., 2020), by precautionary approach we should stop their emissions now before the amount is so high that the damage is irreparable. From that perspective we need to identify best practices to improve sustainable consumption and waste behavior that prevent microplastics.

The environmental threat represented by microplastics has promoted reactions at international and national level. The industry of plastics and allied associations created the *Global Plastic Alliance* aiming at a better global management of plastics (Marine Litter Solutions, 2019). The United Nations (UN) have, literally, declared war on ocean plastics (UN, 2017), and clean oceans to sustain marine resources is one of the UN Sustainable Development Goals, specifically SDG 14 (UN, 2021). There are international campaigns addressed to companies to urge them to redesign the use and disposal of plastic, like the WWF initiative *ReSource* launched in 2020 (https://resource-plastic.com/; accessed February 2021). After the first international conference on microplastics in Lanzarote (Spain) in 2016, the *Lanzarote Declaration* (SAM, 2018) has been followed by country efforts to reduce microplastics emissions, including bans to cleaning products with microplastics. They are today being considered at EU level, although their implementation seems to be difficult under current international rules of the World Trade Organization (Kentin & Kaarto, 2018). Da Costa et al. (2020) point at many norms, regulations, laws, and recommendations proposed and implemented in the last years to mitigate (micro)plastics in the environment, principally based on levies or bans, although for these authors the real benefits of these norms are still to be proved. In this subject governance seems to follow a top-down strategy, with companies and politicians starting changes without a wide demand from the society. Da Costa et al. (2020) concluded that, beyond regulations, consumers have to adjust their behaviors, and, together with manufacturers, adhere to a culture of reduction, reuse, and recycle. For the adoption of these pro-environmental behaviors psychosocial approaches are needed, especially regarding the specific problem of the invisible, overlooked microplastics.

3.2.2. Psychosocial interventions: theoretical frameworks

As for other subjects in environmental and health psychology, the main theoretical framework that could be applied in pro-environmental consumption and waste behavior is the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and its further development as the Theory of Planned Behavior (Ajzen & Madden, 1986; Ajzen, 1991; Ajzen, 2002). Individual behavioral intention is determined by subjective norms –the individual thinks it is acceptable by their referents–; by attitude –the individual is favorable to that behavior–; and by the perceived control –the individual thinks they can do it–. Perceived behavioral control also influences the actual behavior, not only the intention to behave. This theory has been widely applied in studies of recycling behavior. For example, Tonglet et al. (2004) found a significant effect of the attitude, perceived control and social norms on the intention to recycle in Brixworth, UK, with the concern and previous recycling experience being significant predictors of actual recycling behavior. In other cultures, the theory has been applied too, like in China, where attitude, perceived norms and subjective norms significantly influence the use of plastic bags (Sun et al., 2017). The theory is likely applicable to behaviors against microplastics emissions as well. Although this research field is very new, the influence of attitude and behavioral control on the intention to purchase clothes not emitting microfibers has been already proven in USA (Nam et al., 2017).

In the Value-Belief-Norm theory, pro-environmental behavior (or behavior intention) is predicted from values, awareness of consequences, ascription of responsibility, and personal norms (Chen, 2015; Stern, 2000). Environmental knowledge itself does not induce pro-environmental behavior (Kollnuss & Agyeman, 2002); however, it will do depending on social norms, feelings of guilt and attitude (Mohiuddin et al., 2018). These authors extended the Theory of Planned Behavior adding values as a variable that affects consumer behavior in emerging countries like Malaysia, where although knowing the importance of using green vehicles, the effect of subjective norms may be not significant for their actual use (Mohiuddin et al., 2018); in other words, consumers may have the knowledge but if they do not have the values they will not buy green products. Henderson and Green (2020) found similar gaps in the fields of plastics consumption and its potential contribution to microplastics emissions: although people were aware of plastic pollution (not so much about microplastics), plastic consumption was valued as positive for hygienic issues thus that behavior was not changed.

Regarding sustainable consumption, the relationship between expectation and perception is a key determinant of final consumer's behavior. Individuals compare their expectation with their perception of a product and if the expectation is met, they will purchase the product. Tsioutsou (2006) found that perceiving the quality of a product and its adequacy to consumer's values – the environmental quality in the case of sustainable products- increases consumer's satisfaction and also the probability of purchasing the product. This theory could be applied to the consumption of products to reduce microplastics emissions; Herweyers et al. (2020) found that Belgians would buy devices to retain microfibers in washing machines only if they are really effective.

3.2.3. Objectives and departure hypothesis

This study aimed at analyzing current literature about psychosocial implications of the microplastics crisis and how they could be applied in the mitigation of that global environmental crisis. Identifying main psychosocial frameworks involved and research gaps will contribute to design future research.

From the characteristics of microplastics and the theoretical frameworks above, we expected that psychosocial research studies focused mainly on the following issues:

1) Microplastics perception (for microplastics invisibility),
2) Knowledge sources (explaining public views and top-down governance),
3) Awareness of microplastics risks (still unknown for the novelty of the environmental threat), and
4) Environmental values (important to stop emissions of both primary and secondary microplastics).

3.3. Methods

3.3.1. *Protocol*

A systematic literature search was conducted following PRISMA methodology (Preferred Reporting Items for Systematic reviews and Meta-Analyses; Moher et al., 2009), with minor modifications for the novelty and social impact of the topic.

3.3.2. *Eligibility criteria*

The bibliographic search aimed to identify key literature where psychosocial aspects of the global microplastics crisis are addressed. Geographical or temporal limits were not set. Language limits were not employed, but the search was done using only English words so that most articles retrieved were in English. The search was done in January 2021 ending on the 31st.

3.3.3. *Data source*

Database selection can have a large effect on conclusions from reviews, especially in interdisciplinary topics, thus following the recommendation of Harari et al. (2020) we have explored databases with different level of specificity: Psychology, PsycINFO; Social Sciences, ERIC and Social Sciences Citation Index; interdisciplinary, Google Scholar, PubMed, ScienceDirect. They were supplemented with manual searches for references (forward search) and references of other reviews (backward search).

3.3.4. *Search*

Search terms were: Microplastics, microfibers, microbeads, the abbreviation MP (because it is frequently employed in specific literature about microplastics), marine litter, litter, plastic; psychology, psychosocial, interventions, plastic, theory of planned behavior, knowledge, perception, social norms, risk; review, perspectives, meta-analysis, focus, research. The terms "microplastics" and "psychology" were employed simultaneously in all searches. Considering the enormous volume of recent articles about microplastics published in environmental sciences were tried to follow a conservative search strategy in order to exclude information limited to the environmental point of view. For this, the Boolean terms used in search were: "AND" for at least one microplastic-related and one psychology-related terms were employed, to retrieve as many as possible relevant references; "OR" of "AND/OR" when multiple terms referred to any of the two main topics (microplastics and/or psychology) were employed together in the same search.

3.3.5. *Study selection*

Strict quality filters for eligibility were chosen because the novelty and potential implications of microplastics for human and environmental health attracts an enormous interest of media, environmentalist NGOs, plastics lobby and companies and conscious citizens. However, as commented above the scientific support of many articles and press releases is unclear. For this reason, we have retained only peer-reviewed articles and studies, or reports issued by authoritative institutions and organizations of international relevance such as UN, UNESCO, FAO, Academies. Employing the criteria described above a total of 994 articles was retrieved. All articles complying with the selection criteria were selected. These criteria were the following:

1) Academic peer reviewed article.

2) Participant characteristics: filters for age, gender or occupation were not set. The sample could be comprised of individuals of any gender and age (adults and/or children).

7) Admissible study designs: qualitative, correlational, experimental, as well as reviews and perspectives.
8) Construct being researched: any psychosocial trait.
9) Time range: no limits were set, but microplastics is a relatively recent issue and studies before 2000 are not expected.

Exclusion criteria were (in addition to a failure to comply with the inclusion criteria outlined above):

1) Articles published in conference communication format.
2) Books where peer-review was not stated.
3) Unpublished theses and dissertations.
4) Articles published in popular science magazines.
5) Articles published in media and social media.

3.3.6. *Data collection process*

A form was designed to enable the data from the studies included in the systematic review to be extracted, summarized, presented and critically evaluated. This form was organized in spreadsheet format. The following data were collected from each eligible article:

15) Digital object identifier (DOI).
16) Internet link where the article can be found.
17) Authors.
18) Year.
19) Journal.
20) Title.
21) Country/ies.
22) Sample size (or sizes if there were several studies in the same article).
23) Gender ratio (proportion of females)
24) Age (range and/or mean with standard deviation).
25) Scope (national, international, local).
26) Study design.
27) Instruments.
28) Variables.
29) Raw data (link to them if available in a repository).
30) Summary of results (one to three sentences).
31) Summary of conclusions (one-two sentences).
32) Key words.
33) Abstract

3.3.7. *Data list*

Once the articles complying with the established eligibility criteria were selected, a coding manual was designed, along with a protocol for registering the characteristics of each study. The aim was to guarantee the coding process is transparent and replicable. An ad hoc scale was compiled in accordance with Rubio-Aparicio et al.'s recommendations (Rubio-Aparicio et al., 2018), organized in three general categories:

A. Methodological variables: these refer to the type of design used, and the research methods applied during the studies, the quality of the measures obtained, and the procedures followed for the data analysis. This category contained the following variables:

A.1. Type of microplastics in the study framework (1: primary; 2: secondary; 3: any type).
A.1. Sample size.
A.2. Assessment instrument used to evaluate the variables (measures used e.g., willingness to pay; too diverse for simple coding).

A.3. Dimensions or variables included in the assessment instrument (1: knowledge; 2: perceived efficiency/control; 3: awareness; 4: attitude; 5: concern; 6: engagement; 7: risk perception; 9: pro-environmental behaviour).

A.4. Design used (1: qualitative; 2: quasi-experimental; 3: correlational; 4: experimental).

A.5. Data collection (1: online or by convention mail or telephone; 2: at the workplace or in the interviewees' homes; 3: in public spaces).

B. Substantive variables: sociodemographic characteristics of the sample and characteristics of the treatment, as well as to the research context. This category included the following criteria:

B.1. Age of the sample.

B.2. Percentage of women.

B.3. Target population sector/s (e.g., general public, university or school students, fashion industry, environmentalists/environmental workers; too diverse for simple coding).

B.4. Education background (e.g., main formation discipline, educational level – too diverse for simple coding).

B.5. Characteristics of the specific tool/s employed in the treatment (1: brochure/information in writing; 2: oral information; 3: hands-on activities to visualize microplastics).

C. Extrinsic variables, referred to those characteristics which have nothing to do with the object of study, but which may be associated with the results. Those included:

C.1. Year of article publication.

C.2. Country or countries where the study was carried out.

3.3.8. *Risk of bias in individual studies*

Bias risk assessment was not carried out for the studies included in the review, since the issue has been scarcely studied to date and the number of available studies was small.

3.4. Results

3.4.1. *Article selection: Analysis of specific issues related with microplastics*

A descriptive analysis of articles reporting new data on psychosocial issues directly related with microplastics was done addressing different aspects like the geographical and temporal coverage, the microplastics type (primary or secondary microplastics), the methodology (observational or experimental, qualitative or quantitative), and especially the psychosocial variables considered. Dependent, independent and mediator/moderator variables were identified. Articles about perspectives or reviews on psychosocial factors involved in microplastics, generically called here synthesis papers, were analyzed from the perspective of their objectives and the main recommendations.

The main foci of research were explored using two different approaches. First, we analyzed the use of keywords using a categorical classification and contingency statistics to compare synthesis papers and articles with new data, in order to evaluate the current state of the art in this novel discipline. Keywords were extracted from the list of keywords in each article and classified in five categories: Actors (individuals,

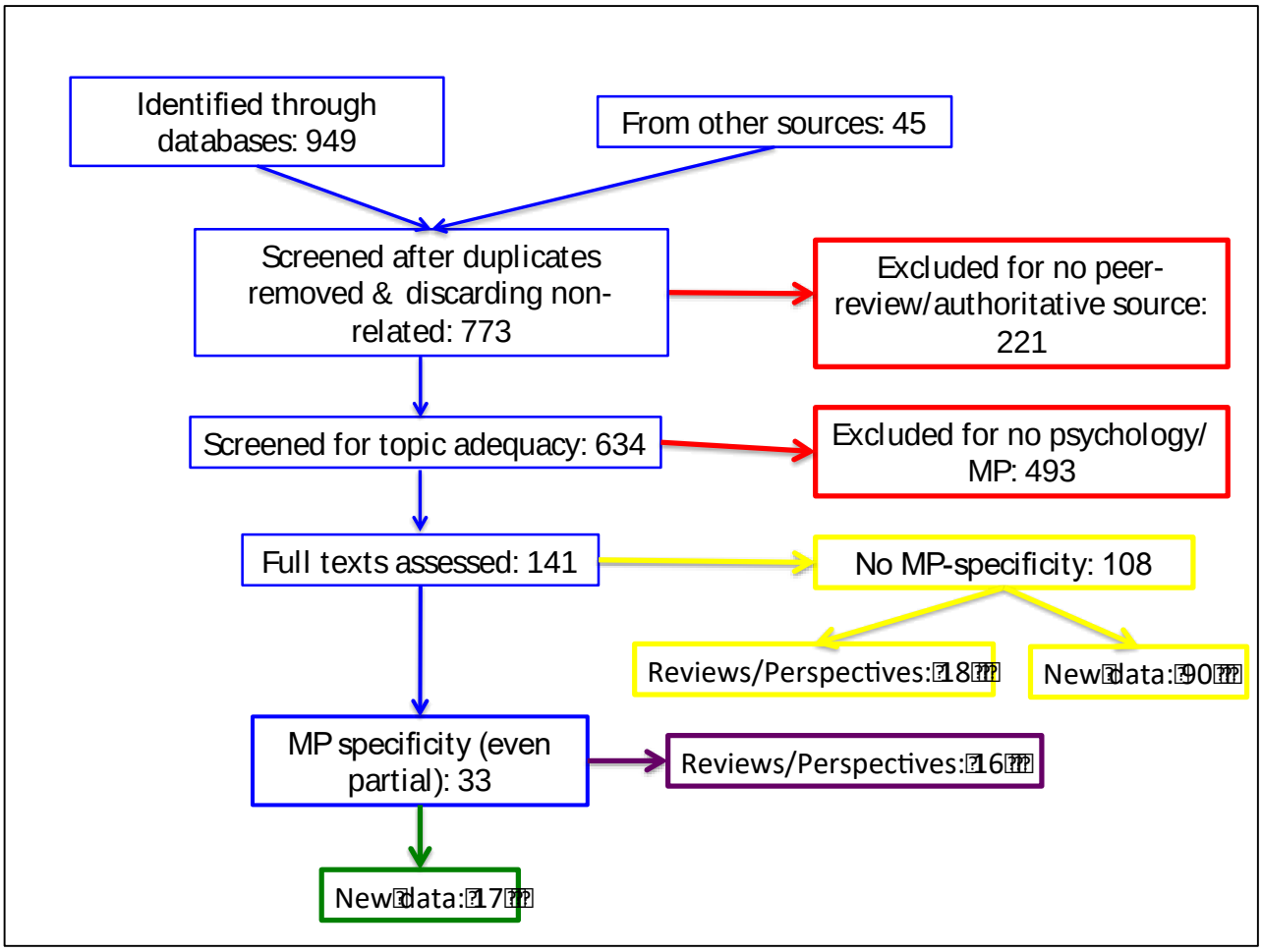
collectives), Goods (affected by microplastics), Pollutants (microplastics, microfibers, litter, nanoplastics), Solutions (explored, proposed, or sought) and Understanding (perception, knowledge, awareness, risk perception). Two minimum occurrences of a term in the whole dataset were considered, to not overweight very specific singletons (keywords used only once). Comparison between the use of keywords between the two types of papers was done using exact Fisher's test and Cramer's V to estimate the effect size. SPSS © version 26 was employed.

Second, we did a cluster analysis of key terms, following Klingerhöfer et al. (2020) analysis of keywords. Here we have also added the titles and texts of abstracts to enrich the number of eligible terms, given the scarce number of articles found. The free software VOSwiever version 1.6.15 (van Eck & Waltman, 2010) was employed to create a network-based map. When keywords, titles and abstracts were included we used the following settings: binary counting; thresholds of 4 minimum occurrences of a term and the 60% most relevant terms selected. Common methodological terms like item, program, study, or subject/participant were eliminated from the selected list of terms.

The number of results found in the literature search using the strategy described above (994) was disproportionately large in comparison with the scarce number of articles containing real information about microplastics and psychology at the same time, only 33 (3.3%) see Figure 3.1. Other 108 articles (10.8%), yellow box in Figure 3.1, contained information of psychosocial nature (perception, knowledge, behavior…) related with plastics, trash, and marine litter. In these articles, as in others discarded in previous steps, microplastics were mentioned as a potential product or consequence of degradation of bigger litter objects, or even as an environmental threat, but were not specifically treated in the study even in a partial or indirect way.

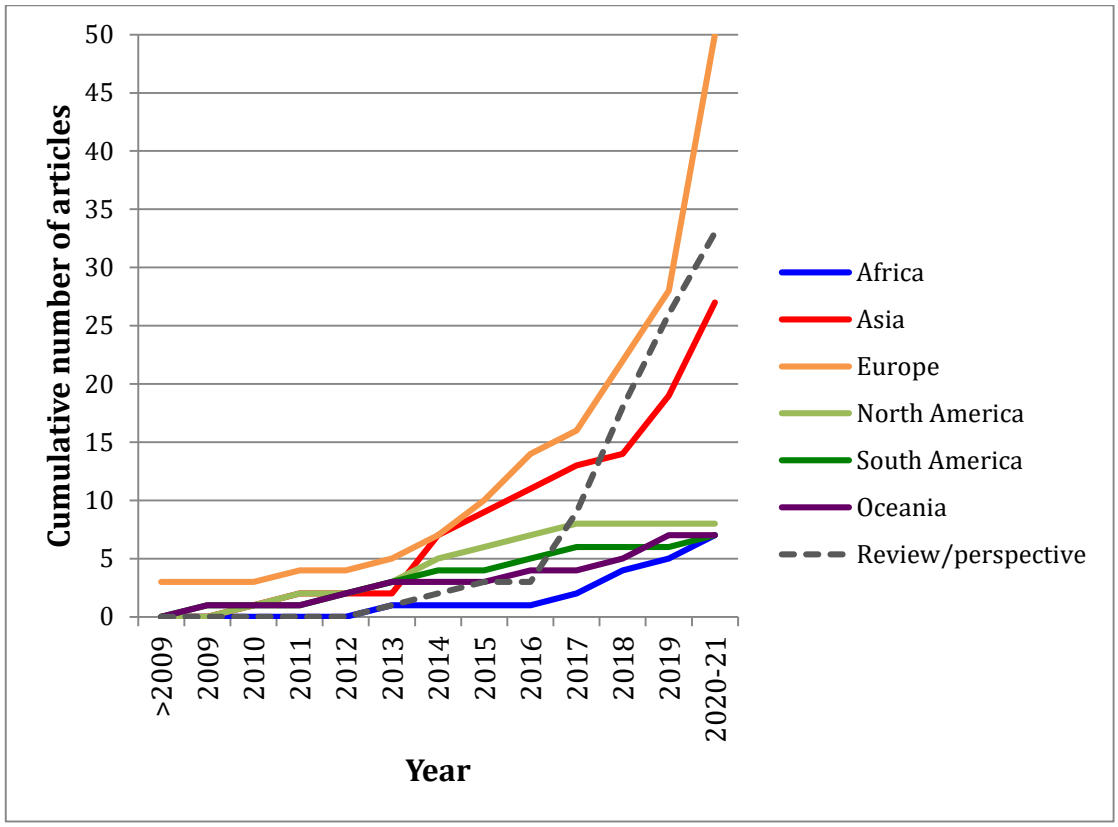
Almost one half of the articles retained with psychosocial issues related with microplastics were reviews or perspectives (16 articles, purple box in Figure 3.1; references listed in Supplementary table 3.1), whereas only 17 (51.5%) contained new data of diverse nature, green box in Figure 3.1. In contrast, only 17% of the articles generally related with plastics and marine litter were reviews or perspectives while the majority contained new data (Figure 3.1). For the nature of the secondary microplastics, which are derived from previous litter, it is obvious that all the behavior related with litter will be indirectly related with microplastics, preventing or promoting their load in the environment and food. However, for the easier perception and visibility of the impacts caused, the psychosocial determinants involved in pro-environmental behavior related with general trash and plastics are not expected to be the same as those involved in invisible microplastics. For this reason, in our study we have not analyzed thoroughly the 108 papers (18 reviews and 90 articles with new research data) indirectly related with microplastics that are outside the focus of this review.

Figure 3.1. Flow diagram summarizing the number of retained (in green and yellow) and discarded (in red) articles in different steps. MP: microplastics.



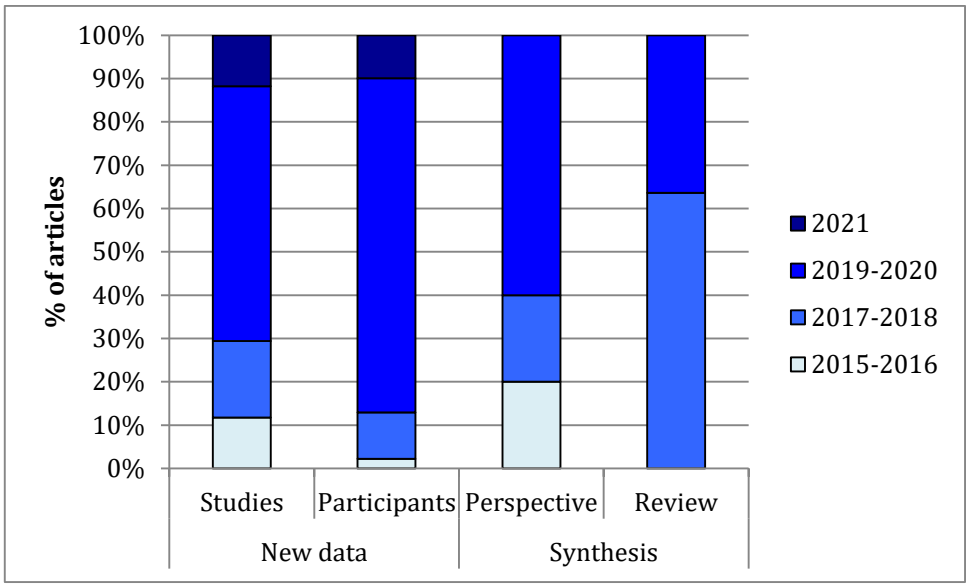
The majority of articles fully assessed (N = 141) related directly or indirectly with microplastics had a very unbalanced geographical coverage (Figure 3.2): most studies were carried out in Europe, followed by Asia and the reviews, then the rest of continents at a distance. The studies focused on Africa were clearly fewer and started growing the latest of all the continents, after 2017.

Figure 3.2. Regional context of research on psychosocial determinants involved in marine microplastics crisis. Cumulative number of articles fully assessed in this review by continent.



The studies with original research data addressing the subject of psychosocial determinants of microplastics pollution are very few to date (Figure 3.1). All of them have been published since 2015 (Figure 3.3), with a noticeable concentration in the last year. Although this review was done in January of 2021 there were already two articles with new data (11.8%) published in 2021. The number of participants was larger in studies conducted since 2019 (see the second column in Figure 3.3), demonstrating the increasing importance of this research field. Review articles (purple box in Figure 3.1, listed in Supplementary table 3.1) comprising self-named reviews (11) and perspectives (5) about the relationship between psychology and microplastics, indeed also increased the last years (Figure 3.3).

Figure 3.3. Proportion of articles published about psychosocial aspects directly involved in microplastics mitigation in different years since 2015. Categories are: synthesis articles (reviews and perspectives), and articles containing new research data with the number of studies and participants on these studies by two-year periods.



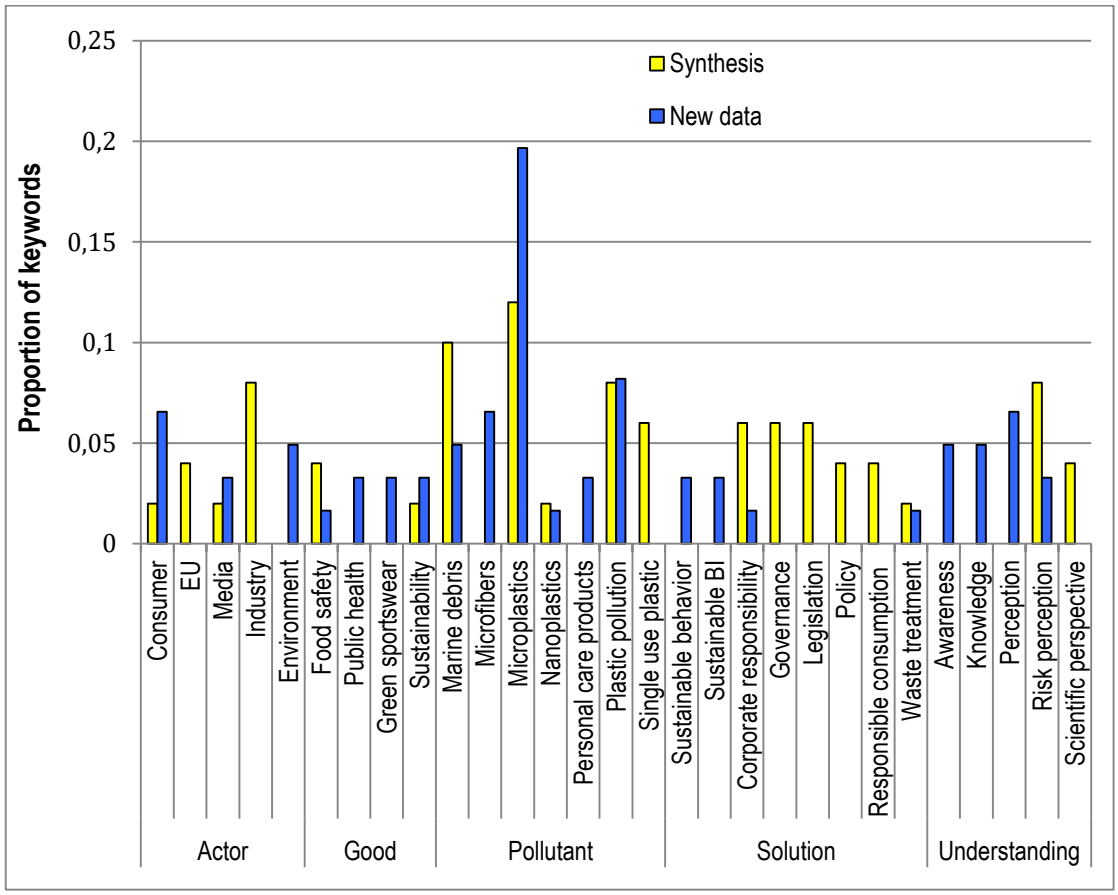
Articles with new data were published in 13 journals mainly of environmental governance and health scope (Table 3.1). Two journals published more than one article: *Marine Pollution Bulletin* (5) and *Sustainability* (2). Regarding the geographical context (Table 3.1), the majority has been conducted in Europe (11 studies, 6797 participants), followed by Asia (three studies, 1282 participants in total) and North America (three studies: two summing 717 participants and one using tweets of Twitter networking site as data source). Peer-reviewed studies from Africa or Oceania were not found.

3.4.2. Study characteristics: Psychosocial issues specifically involved in the microplastics crisis

The analysis of keywords evidenced that psychosocial research was done with different foci in review/perspective articles and in articles with new data (Figure 3.4). Considering wide categories of keywords, the two types of studies were significantly different (Fisher's exact test with $p = .04 < .05$, moderate Cramer's $V = 0.28$), Pollutants being the category with more keywords in both types (38% and 44.2% in synthesis and new data papers respectively) followed by Solutions (28%) in reviews and Understanding (19.7%) in articles with new data. Considering all the keywords separately the difference was highly significant ($p = .00005 < .001$ with relatively strong Cramer's $V = 0.57$). Actors were principally industry (corporations) and large collectives as the EU in the reviews, in contrast with the most frequent keyword of this category in articles with new data: individual consumers (Figure 3.4). A big difference was the type of solutions highlighted. Corporate social responsibility, legislation and governance were keywords more employed in reviews/perspectives, while sustainable individual behavior and behavioral intention were more frequent

keywords in articles with new data (see Figure 3.4). The category Understanding was very different too. While synthesis articles focused on the perception of risk posed by microplastics followed by scientific perspective, new data focused on individual knowledge, perception of microplastics and awareness instead. Summarizing this comparison between the two types of articles, current research is measuring the individual perception and knowledge of these small particles, whereas authors thinking on prospective application of psychosocial tools to mitigate the current microplastics crisis are more focused on global solutions pushed by the perceived risk and science.

Figure 3.4. Use of keywords in reviews and perspectives (*n* = 50) versus articles with original data (*n* = 61). Results are presented as the frequency of each keyword in each category of papers. BI, behavioral intention.



In the map created from terms employed in the title, abstract and key words of research articles with original data (Figure 3.5), knowledge was a central and most important term (with highest weight), clustered with microplastics pollution and consumer's perspective (Cluster 1, green). Plastic pollution clustered in Cluster 2 (blue) together with willingness -to pay or to change behavior, while in Cluster 3 (red) microbeads were together with university students (the main subjects in experimental studies), consumers and personal care products. Unlike the perspective articles, here awareness was not retained as an important term; instead, knowledge –that comes before awareness in the development of pro-environmental behavior– was still the

main subject of new psychosocial investigations.

The network map of Figure 3.5 reflects a high weight of consumers and individuals. It could be read as "*Knowledge of microplastic pollution determines consumer's perspective; consumers may will to reduce plastic pollution, and on the other hand several collectives (university students) will change their use of personal care products to reduce microbeads*"

Figure 3.5. Network map created from research articles with original data using VOSviewer software. Titles, keywords, and abstracts were employed to extract significant terms.

Regarding the theoretical framework, or the rationale that supports the study from grounded psychosocial theories (Table 3.1), only a few studies identified by name classic theories like the Theory of Planned Behavior (Ajzen, 1991), in Nam et al. (2017); and the Value-Belief-Norm (Chen, 2015; Stern, 2000), in Jeong et al. (2021). In most articles (Table 3.2), the scientific rationale was introduced straightforward citing studies where the same psychosocial or sociological variables had been applied, without specific references to a consolidated theory that was however implicit. The majority of studies (11 out of 17) referred the importance of knowledge and/or awareness for sustainable behavior, while Abate et al. (2020), Deng et al. (2020) and Yan et al. (2020) highlighted the role of attitude in such behavior. Anderson et al. (2016) and Janouskova et al. (2020) departed from values and beliefs. Didegah et al. (2018) and Henderson and Green (2020) rationales were based on how media or social media shape the public knowledge about this invisible environmental threat.

Although not so often mentioned in the keyword list (Figure 3.4), the psychosocial variable more frequently studied (Table 3.1) was knowledge about microplastics (Chang, 2015; Cammalleri et al., 2020; Deng et al., 2020; Henderson & Green, 2020; Herweyers et al., 2020, and many others), as reflected in Figure 3.6 from

the clustering analysis of relevant terms. Other variables were awareness of their impacts, risk perception as a more specific awareness of environmental or health threats caused by microplastics, concern, intention to behave against microplastics (Table 3.1). In the latter are included the willingness to change consumption habits, and willingness to pay for actions, microplastics-free products or devices for microplastics or microfibers mitigation. A few studies included moderator or mediator variables like perceived control or efficiency, feeling of guilty, social responsibility. Demographic variables considered were age and gender; main socioeconomic variables were the education background and the family income. We have retained one research article where the variable analyzed was not psychosocial but related with the communication and outreach of scientific knowledge about microplastics (Didegah et al., 2018). Didegah et al. (2018) analyzed tweets of different users of Twitter social network about scientific topics. Although it is far from psychosocial variables, communication explains the public knowledge in this topic. This article adds *social media* as a source of information, related with other articles that show media as main public information sources. As shown in those articles, public risk perception will depend on how the sources transmit scientific knowledge.

From the methodological perspective there was an overwhelming number of observational (versus experimental) studies (Table 3.1). Only three could be considered experimental interventions. Chang (2015) informed USA university students about the content of primary microplastics in cleanser products and measured post-intervention intention to refuse the consumption of those products. Cammalleri et al. (2020), working with Italian university students, used a brochure informing about microplastics as intervention and measured knowledge and awareness pre- and post-intervention. Raab and Bogner (2020) designed an educational module to make microplastics visible and tested it in a sample of 450 German primary education students of 9-10 years.

3.4.3 Psychosocial Variables

Main results of the analyzed articles revealed important implications of psychosocial variables in pro-environmental behavior about microplastics. In general, they would support the applicability of the Theory of Reasoned Action (Ajzen & Fishbein, 1980), where knowledge is fundamental to change behavior (or at least behavioral intention). The three experimental studies examined confirmed it. Students informed about the presence of microplastics in cleansing products refused to use them again (Chang, 2015). With their educational module, Raab and Bogner (2020) demonstrated a gain of knowledge about microplastics and increased awareness of daily actions that can be done to reduce microplastics pollution, while a simple informative brochure was enough to increase awareness in university students (Cammellieri et al., 2020) (Table 3.1). Other observational studies went in the same direction: individuals better informed and more concerned about microplastics would pay more for cleaning the environment (Abate et al., 2020), for a device to filter microfibers (Herweyers et al., 2020), or intend to reduce microplastics emissions (Deng et al., 2020) and to buy sustainable clothes (Yan et al., 2020); in contrast, unaware individuals would provide little support to cleaning campaigns (Choi & Lee, 2018).

Table 3.1. Summary of articles with new research data analyzed in this study. Type of microplastics: P, primary; S, secondary. Gender: % of females. WTP, willingness to pay. MP, microplastics; MPF, microplastic fibers; NP, nanoplastics. BI, behavior intention. SD in parenthesis.

Reference	Country	MP type	N	Gender	Age	Subjects	Study	Rationale	Main variables	Relevant results
Abate et al 2020	Norway	S	1804	49	44 (17.21)	Online survey	Quantitative	Knowledge & attitude determine behavior	Concern, perceived efficiency, WTP	Concerned respondants and those believing in the effect of proposed measures: >WTP. Males less concerned but, for the same concern, willing to pay more.
Anderson et al 2016	England	P	22	90.9	16 - >55	Three focus groups	Qualitative	Beliefs & values determine awareness	Awareness, attitude	Only aware participants support MP reduction for innecessary and unnatural. Public outreach needed to phase out microbeads
Cammalleri et al. 2020	Italy	S	151	59.6	22.5 (6.16)	University students	Quantitative, quasi-experimental	Knowledge & awareness determine behavior	Knowledge, awareness	Main info source Internet. Awareness increased significantly after information in less formed/specialized students
Chang 2015	USA	P	175	-	-	University students	Quantitative, quasi-experimental	Knowledge & awareness determine behavior	Knowledge, awareness, intention to change consumption	Majority of consumers unaware of MP in products; after information, refused to consume the product again
Choi & Lee 2018	Korea	Any	400	47	43 (8.9)	Households	Quantitative	Awareness determines behavior intention	Awareness, WTP	Low perception of MP and of MP risk. WTP for cleaning the ocean, only 50% interviewees
Deng et al 2020	China	S	437	45.3	18-60	General public	Quantitative	Perception & attitude determine behavior	Knowledge, concern, Intention to reduce MP emissions	Knowledge but not concern increases intention. Females & environmental workers stronger intention.
Didegah et al 2018	Canada Denmark	Any	-	-	-	Social networks	Quantitative	Twitter a vehicle for engagement	Tweet consultation & dissemination	Twitter as important source to communicate knowledge about MP; undigested dissemination of scientific facts
Henderson & Green	UK	S	42	66.7	20-77	Six focus groups	Qualitative	Media shape MP discourse & public	Knowledge, awareness,	MP information from media. Barriers to change: undetectable scale, poor

2020								awareness	engagement against MP	understanding of science, cultural ideas about plastic. Disconnection plastics use - distant ocean pollution.
Herweyers et al 2020	Belgium	S	638	69	Adults all ages	Two online surveys	Quantitative	Environmental knowledge influences buying behavior	Knowledge, awareness, WTP for devices against MPF	Despite little MPF awareness, intention to buy preventive device. Mediators: price & perceived environmental benefits. Awareness younger>older.
Janouskova et al 2020	Czech Republic	Any	384	NA	NA	University students	Quantitative	Knowledge, awareness & values determine behavior	Knowledge, awareness	Knowledge from mass media; little awareness; significantly lower awareness in humanity students
Jeong et al 2021	Korea	Any	445	48.8	20-69	Online survey	Quantitative	Value-Belief-Norm theory	Knowledge, risk perception, proenvironmental BI; social responsability, feelings of guilt	Risk perception affects pro-environmental behaviour, influenced by knowledge. Guilty & social responsibility mediators.
Misund et al 2020	Germany Norway Portugal	Both	3018	50	19 - 74	Online survey	Quantitative	Knowledge determines purchasing decisions mediated by price and environmental values	WTP for MP-free products, demographics	MP-free products preferred but will not pay more for them. Cultural differences: WTP Portugal>Germany>Norway.
Nam et al. 2017	USA	S	542	53	18-74	Online survey	Quantitative	Theory of Planned Behaviour + expectation & perception	Intention to purchase green clothes, expectation, perception, attitude	Subjective norm & perception affect attitude, perceived control & intention to purchase. Attitude mediates between perception, expectations & purchase intention. Perceived control does not affect attitude and purchase intention, contrary to expectations
Ojinnaka & Aw 2020	UK	Both	72	68.1	25-54	Ethnic minorities	Focus group	Awareness enhances support to plastic reduction	Knowledge, awareness, WTP	Control support & WTP despite low knowledge. Education & social group associated with awareness. Main information: media. Awareness: MP>NP, environmental>food threats.
Raab & Bogner 2020	Germany	Any	450	-	9-10	Children	Quantitative, quasi-experimental	Knowledge enhance motivation & responsibility	Knowledge, awareness, engagement	Making MP visible through an education module students gain knowledge & awareness and propose actions to reduce MP

Soares et al 2021	Portugal	Both	428	70,8	18-69	Online survey	Quantitative	Awareness, perception, environmental concern & motivation predict pro-environmental behavior	Knowledge, awareness pro-environmental behaviour	Knowledge, perceived impacts & awareness increase proenviron behaviour. Pro-environmental behaviour older>younger
Yan et al. 2020	UK	S	15	53.3	21 - >40	Fashion industry	Qualitative	Knowledge determines attitude and purchasing behavior	Knowledge, awareness of MFP impacts	Unawareness caused by MFP invisibility

3.4.4. Environmental Values

Environmental values are decisive to reduce the consumption of products with microplastics (Anderson et al., 2016), and to purchase green clothes (Nam et al., 2017). However, the perceived control that is key in the Theory of Planned Behavior was not significant in Nam et al. (2017) study, contrary to Ajzen (2002) expectations. Another important factor found in these studies was the concern about microplastics and their perceived risks. The perceived impacts together with knowledge and awareness determined pro-environmental attitudes in the study of Soares et al. (2021) in Portugal; however, concern did not increase significantly pro-environmental behavior intention in the study of Deng et al. (2020) in China. Risk perception was also key in pro-environmental behavior intention in Korea, mediated by guilty and social responsibility (Jeong et al., 2021). Indeed, the relation between expectations and perception has been also important in purchase decisions about green microplastics-free products (Nam et al., 2017).

3.4.5. Sociodemographic Variables

Sociodemographic variables showed different effects on the variables examined depending on the particular study. In the few studies reporting an effect of the gender, females seemed to be more sensitive about this environmental problem than males; for example, females declared stronger intention to reduce microplastics emissions in China (Deng et al., 2020), and would pay more to remove microplastics from Arctic waters (Abate et al., 2020), although in this particular study the effect disappeared and even took the opposite direction, males willing to pay more, after controlling concern (Abate et al., 2020). Age had contradictory effects depending on the study. Older Portuguese would have more pro-environmental behavior than the youngers regarding the control of microplastics emissions (Soares et al., 2021), but younger Belgians would be more aware about the specific problem of microfibers (secondary microplastics derived from clothes) than older ones (Herweyers et al., 2020). In contrast with these variables that have different effect depending on the study, the educational background was consistently related with proenvironmental behavior and awareness about microplastics, individuals with higher education level and environmental background being more sensitive to this issue in different cultures, from the Czech Republic (Janouskova et al., 2020) to China (Deng et al., 2020) to ethnic minorities in the UK (Ojinnaka & Aw, 2020).

3.4.6. Cultural differences

The cross-cultural aspect has been little investigated in studies about microplastics but is likely very important. In countries like Portugal where the trust in the institutions is not very high, individuals would pay more for microplastics-free products than in countries where individuals have higher political-trust like Germany or Norway (Misund et al., 2020). Private (versus public) governance and certification labels to facilitate individual purchase decisions would be more effective in countries with low political trust (Misund et al., 2020). UK ethnic minorities would support economically the control of microplastics emissions even if do not know much about the issue (Ojinnaka & Aw, 2020), and little aware Belgians would buy devices to control microfibers emissions (Herweyers et al., 2020), in clear contrast with German and Norwegian consumers that would prefer microplastics-free products but will not pay more for them (Misund et al., 2020).

3.4.7. Role of mass media

The role of media was highlighted in the analyzed studies. Internet was the main information source about microplastics in the study of Cammelleri et al. (2020), and mass media in Henderson and Green (2020), Janouskova et al. (2020), Ojinnaka and Aw (2020). Articles about microplastics were amongst the most re-tweeted and commented, but the scientific facts described in the articles were disseminated undigested (Didegah et al., 2018), revealing an inadequate outreach of scientific knowledge about this topic.

On the other hand, poor understanding of science was identified as a barrier to change behavior about microplastics in the study of Henderson and Green (2020). Studies worldwide emphasize the fact that there is little public awareness about microplastics (Chang, 2015, in USA; Choi & Lee, 2018, in Korea; Janouskova et al., 2020, in the Czech Republic; Anderson et al., 2016, and Yan et al., 2020, in the UK). All of them mentioned the invisibility of these pollutants as one of the main causes.

3.5. Discussion

When we started this review, we expected that the majority of studies focused on microplastics perception, knowledge sources, awareness of microplastics risks and environmental values. In reality we found a mismatch between perspective studies and those creating new data. Studies with new data were more focused on the knowledge of consumers about microplastics, being synthesis and perspective papers more focused on awareness and risk perception. Environmental values were more frequently tackled in articles with original data and not so much in perspective papers. The sources of knowledge appeared in the two types of articles but were not the main focus and appeared secondarily in keywords. Moreover, perspective studies were more focused on collective actors and new data on individuals; for example, corporate social responsibility is very important but there are very few actual data about how companies –CEO and employees- see the problem of microplastics. These mismatches can be explained from the novelty of microplastics as an emerging contaminant, thus a very recent environmental threat. Science and citizenship walk here at different speeds. While researchers can figure out ways of combatting the new threat, there are still many basic information gaps needed to properly design and implement interventions for public sensitization and enhancement of pro-environmental behavior about microplastics. Examples are how the general public perceives microplastics and how much knows about them. We will discuss some of the relevant findings next.

3.5.1. Psychosocial frameworks to promote sustainable behaviors towards microplastics

One of the first observations in the handle of articles reviewed is the scope of the journals where they are published. Perhaps for the enormous importance and potential impact of the current microplastics crisis, psychosocial implications are being published in journals of a quite generalist scope that interest a wide audience and stakeholders, more than in specialized journals within the field of Psychology. As authors repeat in the examined studies, this subject is still in its infancy (e.g., Pahl & Wyles, 2017). According to this, the theoretical frameworks that support the psychosocial studies, although solid, are not much developed nor discussed in the

articles reviewed. They may be different in primary and secondary microplastics. Behaviors to control the emission of primary microplastics would rely on the purchase of products with microbeads; theories of sustainable consumption are to be applied in this case, while general pro-environmental behaviors are needed to control secondary microplastics emissions, from acquiring plastic-free products to reducing and disposing waste adequately. We have seen in our review, often without naming them, the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and the Theory of Planned Behavior (Ajzen, 1991, 2002), as well as Value-Belief-Norm theory (Chen, 2015; Stern, 2000) and the theory of Perception-Expectation (Tsioutsou, 2006) regarding purchase decisions. These are solid foundations and will be likely used in further studies of the global microplastics crisis. However, under the light of Nam et al. (2017) study, some aspects of the Theory of Planned Behavior like the perceived control could not be verified. Perhaps the perception, attitude and environmental values are enough to determine pro-environmental behavior about microplastics in some cases.

Microplastics is a difficult subject from the psychosocial perspective for two main reasons. One is that being invisible to the naked eye, their perception depends principally on the information received from external sources. This aspect was remarked as one of the main barriers to behavior change regarding microplastics (Henderson & Green, 2020). Another difficulty resides on the insufficient number of objective data about their environmental and health risks they pose. As commented above, the effect of microplastics are accumulative, thus adverse consequences will likely be detected at the mid or long term. Moreover, both primary and secondary microplastics are originated far from the sites where they will accumulate (the ocean). Thus, there is a real spatial and temporal distance between microplastics production and microplastics effects. This lack of evident, rapid association between cause and effect adds to the difficult perception of the real microplastics nuisance, as highlighted by Henderson and Green (2020). Such psychological distance has to be taken into account when targeting potential psychosocial mechanisms that could be used in microplastics management.

3.5.2. Unequal geographic and cultural coverage

The second observation to be remarked is the irregular geographical coverage of specific studies about microplastics, where African countries were absent. This could be expected from the unequal coverage of continents seen in Figure 3.2. This gap can be explained from many reasons like lower investments in science in Africa where many developing countries are located, but not from less microplastics pollution in African waters that produce a large part of the total microplastics emitted today (van Wijnen et al., 2019). Alimi et al. (2021) found a higher level of microplastics in fish collected in Egypt than in any other part of the world; however, we could not find any study about knowledge or behaviors related with microplastics emissions from that country. Oceania was absent, too, but its population is much smaller.

On the other hand, we found indicators of cultural differences in some psychosocial perspectives about microplastics that could be of importance for future interventions to cut microplastics emissions. The level of trust in country's institutions and authorities could have an influence on the individual effort to behave pro-environmentally, as demonstrated in Misund et al. (2020). The effect of some

demographic factors like age and gender varied between countries, like China and Norway for the relative willingness to act (or to pay) of females and males, being higher in females in China (Deng et al., 2020) and the opposite in Norway – controlling concern in this case (Abate et al., 2020). Similarly, youngers were more concerned about microplastics than older citizens in Belgium (Herweyers et al., 2020) and the other way around in Portugal (Soares et al., 2021). This topic should be thoroughly explored, because if these differences are confirmed interventions should be designed ad hoc for each culture and region.

3.5.3. Top-down governance and the importance of science communication

In this study we have observed a clear difference between the perspectives and the studies with actual data regarding the control of microplastics. These are more focused on individual behavior while reviews seem to be more focused on governance. This discrepancy can be explained, at least in part, from the importance of what has been called the *third power* (mass media) in the dissemination of knowledge about microplastics. Scientific facts about microplastics pass rapidly to stakeholders and politicians through media (Volker et al., 2020), and decisions like banning microbeads from European and American beauty products have been made without clear evidence and even without extensive public pressure, which is generally limited to environmentalist sectors very aware of microplastics. We have seen in this review that media are the main source of public information about microplastics. One of the barriers to behavior change concerning microplastics emissions is poor understanding of science (Henderson & Green, 2020). Moreover, Anderson et al. (2016) highlight the need of a better public outreach of science to find more public support and phase out microbeads. Therefore, improving science communication seems to be one of the priorities in the next years, and finding the ways to make microplastics visible is surely one of the first needs.

3.5.4. Limitations of this study

A limitation of the current study is an inevitable cultural bias, since all the articles retained are in English. Peer-reviewed articles included in the Web of Science (WoS), that have been the majority of the papers that passed the filters applied here, are strongly biased towards English language literature (Lillis & Curry, 2010). This is especially important in the present case where we have seen intercultural differences regarding the attitudes towards microplastics (Misund et al., 2020).

Another limitation was the reduced number of articles found passing the quality filters applied. Here we prioritized peer-reviewed published articles, thus unpublished studies like Master or PhD theses were not retained. Surely these studies will be published in the next years, thus revisiting the topics worked in the present study in a few years would be advisable.

3.5.5. Research gaps and recommendations for future research

Future directions of urgent research can be drawn from the gaps found in this study. Some of them are:

1) Coverage of psychosocial perspectives worldwide, especially in Africa where microplastics emissions are important while there is a lack of studies on the psychosocial side.

2) Explore intercultural aspects of the psychosocial issues involved in microplastics mitigation, to be able to better determine the scale of intervention designs.

3) Prioritize studies about how to make microplastics visible to the general public, that is, finding best practices of science outreach about this topic.

4) Investigate the perspectives of companies, politicians and journalists about microplastics from a psychosocial point of view, to involve all actors in the common goal of fighting this emerging global threat.

CHAPTER 4

STUDY 3: BIASED VISIONS OF MICROPLASTICS OFFERED FROM NEWSPAPERS

Publication:

Garcia-Vazquez, E., Garcia-Ael, C., & Juanes, F. (2023). Social perception of microplastics: the role of newspapers. *Environmental Science and Policy*, MS # ENVSCI-D-23-00439, under review.

4.1. Abstract

Microplastics are a global pollutant of concern for all the sectors of the society. Microplastics impacts have been widely publicized by media focusing principally on human health, although the majority of research studies report threats for wildlife and the environment. Here we have analyzed the treatment of microplastics in news published online along the last 15 years by nine newspapers from three countries of different culture and legislation about plastics: the individualistic Canada and the collectivistic Mexico, both with bans on plastics, and the less individualistic Spain where plastic bans are not enforced. Relevant term clustering and emotional content analyses were conducted on 231,468 quality-filtered words. Unlike academic papers mainly focused on measuring pollution impacts, terms referred to understanding and solutions were central in Canadian newspapers, while environmental and food threats were more frequently reported in Mexico and actors were central in Spain. More words of negative emotional charge were employed in the collectivistic Mexico than in the other countries. After COVID-19 pandemics more news reporting microplastic threats on human health were found in Spain and Mexico, while in Canadian newspapers the change was not significant confirming a strong environmentalist focus on this country. Improving science communication strategies would be recommended, especially in Spain where bans on plastics are still to be implemented.

4.2. Introduction: how mass media contribute to public opinion and environmental policies

Microplastics (MP) are plastic fragments smaller than 5mm, that may be either manufactured of that size, like microbeads (primary MP), or be the product of breakage or erosion of larger plastics (secondary MP). They represent an emerging threat for the environment and health. Humans may ingest up to 52,000 MP annually, increasing to 121,000 if taking inhalation into account (Cox et al., 2019). Health risks of MP in humans range from oxidative stress and digestive problems to respiratory diseases, inflammation and allergy (Vethaak & Legler, 2021) and even fertility (D'Angelo & Meccariello, 2021). The same risks also affect animals, from DNA degradation (Masiá et al., 2021) to many other alterations (Tagorti & Kaya, 2022). Plants may retain MP in their structures, altering their chlorophyll function (Li et al., 2020). Thus, the whole ecosystem may be affected (Prata et al., 2021), but long-term effects are still unknown.

The impacts of MP may be intertwined with other global stressors. For example, the degradation of MP in the ocean contributes significantly to emissions of greenhouse gases that cause climate warming (Royer et al., 2018; Shen et al., 2020). Another very important stressor at a global level that has been related with MP emissions was the COVID-19 pandemic in 2020. Various authors have predicted an enormous increase of MP in the upcoming years coming for untreated single-use hygienic masks (Shruti et al., 2020; Parashar & Haik, 2021; Shen et al., 2021). Moreover, changes in lifestyle during the pandemic have likely contributed to increasing the genotoxic effects of MP (Tagorti & Kaya, 2022).

Because MP are invisible to the naked eye, citizens and politicians learn about the abundance and impact of microplastic pollution principally thru mass media (Garcia-Vazquez & Garcia-Ael, 2021; Volker et al., 2020): the Internet (Didegah et al., 2018; Cammelleri et al., 2020), or newspapers and TV (Henderson & Green, 2020; Janouskova et al., 2020; Ojinnaka & Aw, 2020). The information provided by

newspapers about MP is therefore very important for the society to understand MP threat.

Mass media are strategic actors that shape the public's attitudes about a country's policies (Baum & Potter, 2008), influencing both public opinion and decision makers. Environmental issues are not an exception. For example, media discourse helped to account for changes in the support of nuclear power (Gamson & Modigliani, 1989), influence public opinion about biological invasions depending on the charisma of the invasive species (Jarić et al., 2020), and contributed to the rise of climate change on European public agendas (Damsbo-Svendsen, 2022). However, the informative foci of newspapers have been scarcely studied regarding emerging pollutants like MP. The few studies tackling this issue point to biased information about this environmental problem. Although the real health impact of eating MP-polluted seafood is still largely unknown (Barboza et al., 2018), the media coverage exaggerating their potential risk to human health may have fueled consumer alarm not supported by scientific publications (Farady, 2019). Messages transmitted by UK and USA newspapers are principally focused on human health and the human food chain (Volker et al., 2020), while the communication of environmental impacts is secondary. Ballantine et al. (2021) analyzed the treatment of MP in Danish news media and concluded that, besides presenting MP as dangerous for humans and the environment, the media placed MP responsibility on individual consumer behavior. We expect that the link between MP and COVID-19 pandemics will also appear in mass media, since that link has been much highlighted in recent scientific studies (e.g., Shen et al., 2021; Tagorti & Kaya, 2022); however, to our knowledge, the treatment of this issue by mass media has not been studied yet.

As seen above, the literature about communication of scientific results on MP is scarce and has been limited to a few countries so far. The treatment of MP in mass media may be very different depending on countries and cultures. First, the degree of development in a country has been related with a higher degree of environmental concern and green behavior of their inhabitants (do Paço et al., 2013). Countries differ greatly in legislation about MP: microbeads are banned already or are being phased out in some countries, principally in Europe and North America, while the majority of the rest has not instituted microbeads bans yet – especially in Africa and South America (Anagnosti et al., 2021).

The culture context of a country is also important regarding environmental issues. From large-scale surveys involving thousands of participants worldwide, countries have been characterized based on different psychological attributes such as individualism (versus collectivism), where individuals would assume independently personal responsibilities (Hofstede et al., 2010). For example, individuals from collectivistic cultures will pay more for green products (Sreen et al., 2018), or to support the environment (Mainardes et al., 2017). Such trends for collectivistic cultures are thought to reflect an interdependent self-construal, leading to increased concern about the environment because its destruction is harmful for the present and future generations (Arnocky et al., 2007; Deng et al., 2006). In contrast, Komatsu et al. (2019) found that countries with individualistic cultures have lower levels of anthropogenic perception of nature than those where collectivism is dominant. Thus, they would focus on preserving the environment while collectivistic countries would focus more on how environmental threats affect people.

Another cultural dimension considered by Hofstede et al. (2010) that influences environmental behavior is long-term (versus short-term) orientation, i.e., individuals focus on the future more than on the present or the past. Long-term oriented individuals tend to adopt green consumption (Sreen et al., 2018) and exhibit pro-environmental behaviors (Mi et al., 2020) because they expect these behaviors will result in a better future. Journalists from long-term oriented countries are thus also expected to focus on the environment more than those from countries with a shorter-term orientation.

For the importance of mass media to ensure the society is informed about this emerging threat, and their influential role on country policies, knowing how newspapers from different countries and cultures treat MP issues is a critical challenge. Here we contribute to filling this gap by exploring the treatment of MP in digital newspapers of national distribution in three countries of different cultures, degree of national development, and legislation about plastics and MP: Canada, Mexico and Spain (Table 4.1).

4.3. Objective of the study and departure hypotheses

The objective of this study was to investigate intercultural differences in how and when mass media introduce MP issues into the public discourse. Our hypotheses were:

(i) From the influence of mass media discourse on decision makers, the information about MP in newspapers would appear earlier in the countries with earlier enforcement of MP bans; expectedly before the laws.

(ii) Being invisible to the naked eye, knowledge about MP depends on scientific data; however, as in other countries, we expect newspapers emphasize messages about the impact of MP on food and health.

(iii) The content of news published in individualistic, long-term oriented, more developed Canada and Spain will emphasize the actors, environment and solutions while those published in collectivistic, shorter-term oriented and relatively less developed Mexico will focus more on MP threats and how they affect personal goods like food and health.

(iv) To attract readers' attention, headlines will exaggerate the expected intercultural differences, with more mentions about goods versus actors and solutions depending on the relative collectivism of a country.

(v) The COVID-19 pandemics impacted drastically all societies worldwide. In all the countries the focus will change following pandemics, increasing the proportion of news about the impacts of MP on health.

4.4. Methods and statistical analyses

4.4.1. Countries in study and choice of newspapers

In this study three countries with different culture and legislation about MP were considered. The United Nations statistics reports different development indicators for the three countries (Table 4.1), Mexico having lower indicators than Canada and Spain, life expectancy at birth included (UNEDP, 2022). For the World Bank, Canada and Spain are in the group of High Income countries, while Mexico is in the group of Upper Middle Income that can borrow from the International Bank for Reconstruction and Development (https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html). The countries also

differ in cultural traits (Hofstede et al., 2010): the most and least individualist countries are Canada and Mexico respectively, and Spain and Mexico the most and least long-term oriented (Table 4.1).

The legislation about plastics (Muposhi et al., 2022) and microbeads (Anagnosti et al., 2021) is different in the three countries. Microbeads have been banned in Canada since 2017 under the Registration SOR_2017-111- Microbeads in toiletries (Anagnosti et al., 2021), whereas bans of single use plastics have been in force in some cities and are now in force nationally as of 20 of December of 2022 (Registration SOR/2022-138, https://laws-lois.justice.gc.ca/eng/regulations/SOR-2022-138/FullText.html).

In Mexico, DF legislation prohibited all single-use plastics in January of 2021 (*Decreto Congreso Ciudad de Mexico I Legislatura*, of 25 of June of 2019), and the country has proposed a ban of MP in cosmetics in 2020 (Article 269 of the General Law of Health, http://sil.gobernacion.gob.mx/Archivos/Documentos/2020/02/asun_4009153_20200227_1582832039.pdf).

In Spain the situation is different. The Directive (EU)2019/904 of the European Parliament and of the Council, of 5 June 2019, requires the Member States to ensure that by 2030 all plastic packaging on the market is re-usable or easily recycled, and encourages but does not require producers to strictly limit microplastics in their formulations (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0904&from=EN). Applying this Directive, in Spain microbeads are not prohibited, and levies are applied specifically to plastic bags (Royal Decree 293/2018 of 18 of May of 2018).

Table 4.1. Characteristics of the countries analyzed. HDI: Human Development Index (UNEDP, 2022). Cultural individualism is taken from Hofstede et al. (2010). Microbead bans as in Anagnosti et al. (2021); Single Use Plastic bans as in Muposhi et al. (2022) and national legislations.

	Canada	**Mexico**	**Spain**
HDI (rank in 2021)	0.936 (15)	0.758 (86)	0.905 (27)
Human Development	Very High	High	Very High
Life expectancy at birth	82.7	70.2	83.0
World Bank Group	High income	Upper middle income	High income
Language	Anglophone & Francophone	Hispanic	Hispanic
Microbead bans	Yes	Ban of MP in cosmetics	No
Single Use Plastic bans	Bans by city	Bans by state	Taxes on plastic bags (countrywide)
Individualism	80	30	51
Long-term orientation	36	24	48

Volker et al. (2020) analyzed five anglophone online newspapers with a large readership and a broad political spectrum. Here, three newspapers were randomly selected in each country from a list generated combining three criteria: the most number of readers, publication at a national level, and political spectrum (conservative, progressive and liberal) (Supplementary Table 4.1).

4.4.2. Methodology

The digital version of the selected newspapers was searched online for news containing information about microplastics.

Period of search: From any date to July 2022.

Search engine: Google

Search term: Microplastic* (English) or Microplástico* (Spanish)

We used similar search terms including the name of the respective newspaper and "microplastic*". First exploratory searches included "plastic pollution", "plastics", "plastic particle", "microbeads", "risk", and/or "microfiber", with "and" and "and/or" Booleans, but the results did not improve the search done with "microplastic*".

The following quality filters were applied:

a) Irrelevant news, like commercials or brand publicity containing the word "microplastics".
b) Words like fillers, conjunctions, prepositions and articles.

After the application of quality filters, the total number of words retrieved and analyzed was 38 125, 60 521 and 132 822 in Canadian, Mexican and Spanish newspapers, respectively. For further analysis the Spanish texts were blind translated to English (Jackson et al., 1983).

4.4.3. Data analysis

Analysis of text words was done to identify the relevant words employed and the relationships between them. VOSViewer (Van Eck & Waltman, 2010) free software was used with the following settings: 15 minimum occurrences of a word, binary counting, 60% of relevant terms excluding commonplace words, normalization method of association strength.

Up to 100 relevant terms related to microplastics were selected from the word list obtained from the first analysis of term relevance of the three countries, considering those occurring in at least two countries and at least 10 times in the dataset. The key words were classed based on Garcia-Vazquez and Garcia-Ael (2021) in any of the following categories: goods, actors, pollution, solutions, and understanding. The goods were classed into three categories: food, health and environment. For analysis terms closely related terms like "Scientists" and "University" were grouped into a single class, in this case "Academy".

Cluster analysis was done, and network maps were constructed from headlines using VOSviewer. In this case the minimum number of occurrences was 5, clustering resolution 1, merging small clusters. The weight for visualization was applied from occurrences.

The emotional content of the words appearing in the "Understanding" category was also considered. We tried two different approaches for the classification

of these words. One, similar to Park et al. (2020), is based on the Circumplex Model of Affect (Russell, 1980) with two dimensions of arousal (high/low) and valence (pleasure/displeasure). The other classification (Aslam et al., 2020) is based on the polarity of words (positive, negative, neutral).

Comparisons among countries for the number of articles in each category was done using contingency statistics based on Chi-square contingency tests and Cramer's V as an estimator of effect size. The difference in the proportion of news describing the impact of MP on human health before and after the COVID-19 pandemics was tested employing risk /odds ratio approach, as in Ardura et al. (2021). These tests were done employing the free software PAST (Hammer et al., 2021).

4.5. Results

The results found from the search done on digital newspapers are summarized in Table 4.2. In Canada, where microbead bans started in 2017, the first news appeared as early as 2007, while in Mexico and Spain mass media started to pay attention to MP impacts much later (Table 4.2). This supports Hypothesis (i). After the application of quality filters, the number of news retained for analysis was more or less balanced across countries: 121, 228 and 293 from Mexico, Canada and Spain respectively.

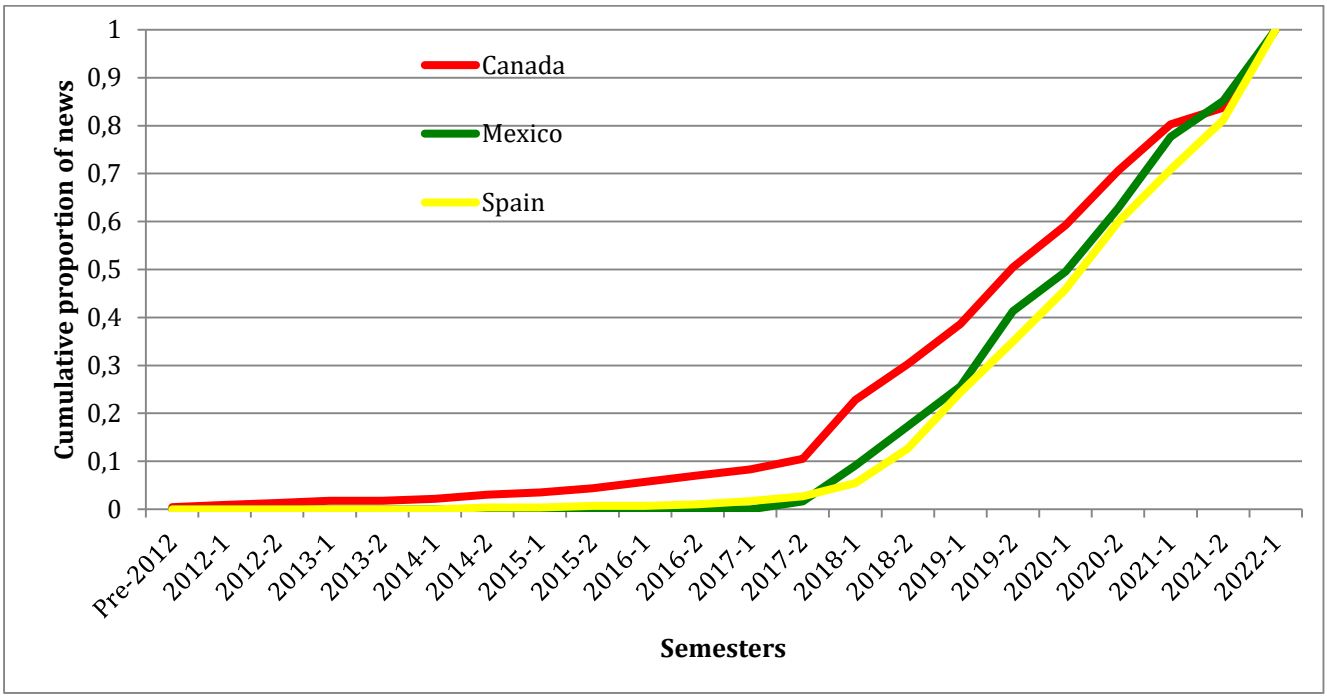
Table 4.2. Overview of the news found using the described search methodology. Letters A, B and C indicate the first, second and third journal to publish news about microplastics analyzed in this article. The proportion of news retained after the application of quality filters is indicated.

	First news about MP (year)	News retrieved	Proportion of retained news
Canada			
C-A	2007	80	0.88
C-B	2012	143	0.78
C-C	2016	78	0.90
Total		301	0.84
Mexico			
M-A	2017	393	0.22
M-B	2018	30	0.7
M-C	2020	83	0.18
Total		506	0.24
Spain			
S-A	2014	110	0.86
S-B	2018	260	0.67
S-C	2020	117	0.31
Total		487	0.63

The evolution of news about MP was similar in the three countries (Figure 4.1). Canadian articles describing MP pollution started first, followed by Spanish and Mexican ones. The oldest article retrieved in our search was from a Canadian newspaper, in November of 2007. The first article about MP in Spanish newspapers retrieved in our study was published in December of 2014, and in the Mexican

newspapers examined, October 2017. The growth of publications was exponential, with a pronounced increase starting mid 2017 in all three countries (Figure 4.1), also the year microbead bans entered in force in Canada. In Mexico a ban on microbeads in cosmetics was published in 2020, and in Spain they are not banned. Coinciding with the respective strictness of MP legislations in each country, the Canadian line was consistently above the Mexican, and this one over the Spanish, until 2021.

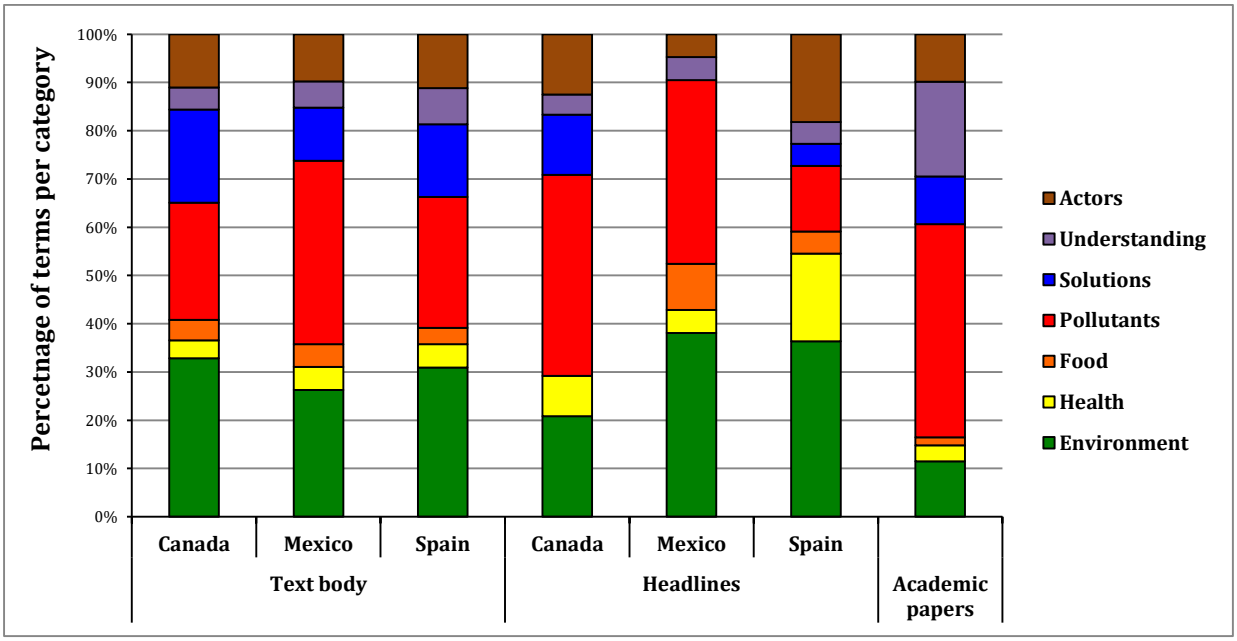
Figure 4.1. Temporal evolution of the news about microplastics in the newspapers analyzed from Canada, Mexico and Spain. Results are presented as the cumulative proportion of the total number of news per country over semesters.



4.5.1. Topics and foci of news about microplastics

A list of 100 relevant words related with microplastics appearing in the news with a minimum frequency of n = 10 was produced (Supplementary Table 4.2). The number of occurrences of these words in the analyzed newspapers was 3494, 4851 and 7647 in Canada, Mexico and Spain respectively. The content was different in the three countries (Figure 4.2, columns at left), with highly significant differences in the proportion of terms within the considered topics: $\chi^2 = 359.65$ with 12 d.f., $p << 0.001$, low effect size with Cramer's V = 0.106. As expected in Hypothesis (iii), news and articles published in the individualistic, longer-term oriented and highly developed Canada and Spain contained a higher proportion of terms related with the environment (32.9% and 30.9% respectively), actors (11.1% in the two countries) and solutions to MP pollution (19.4% and 15.1% respectively) than those published in Mexico (26.2%, 9.8% and 11% in the categories of environment, actors and solutions respectively) (Figure 4.2). Terms related with pollutants, i.e., threats, and with health and food goods, were more frequent in the collectivistic and relatively less developed Mexico (38.1% pollutants, 9.5% goods) than in the more individualistic Spain (27.1% pollutants, 8.2% goods) and Canada (24.3 pollutants, 7.9% goods) (Figure 3.2), also supporting Hypothesis (iii).

Figure 4.2. Proportion of terms in different categories in newspaper text bodies and headlines related with microplastics, and in academic articles. Data for articles published in academic journals (*n* = 64 relevant terms from articles about psychosocial issues related with MP) are from Garcia-Vazquez and Garcia-Ael (2021).



The most frequent term in the category "Actors" was "Academy" in the three countries, but the rest were different (Supplementary table 4.1). The second in frequency was "Government" in Canada, "Industry" in Mexico and "Fashion" in Spain. The third was, respectively, "Job", "Government" and "Team". The actors were significantly different among countries (contingency analysis with $\chi^2 = 233.3$, $p < 0.001$ and C = 0.24). The terms within "Environment", "Food" and "Health" were also different among countries, as it is logical for regions with very different ecology, resources and development levels (contingency analysis was highly significant for the three categories, data not shown).

The terms appearing in the category "Solutions" were also different ($\chi^2 = 445.5$, $p < 0.001$ and C = 0.3), with "Ban" the first in Canada followed by "Recycling" and "Cleaning", while in Mexico and Spain the order of terms in frequency was the same: "Recycling", "Reducing" and (sustainable) "Consumption".

The frequency of terms in the category "Understanding" (Table 4.3 top) was significantly different in the three countries ($\chi^2 = 56.774$, $p << 0.001$, moderate V = 0.198). More positive and neutral than negative terms were found in Canadian and in Spanish news, while in Mexican news more negative terms were employed (Table 4.3 bottom). The results for the valence (pleasure/displeasure) were the same, with more pleasant terms in Canadian and Spanish news and more unpleasant terms in the Mexican newspapers analyzed. Regarding arousal, in the three countries the majority of terms indicating understanding of MP could be classified as of low arousal. In Mexico and Spain, the difference between the low and high arousal was less marked than in Canada (Table 4.3).

Table 4.3. Emotional content of the terms reporting understanding about microplastics employed in the Canadian, Mexican and Spanish newspapers considered. Results are presented as proportion of terms. In parentheses, total number of words within the category of understanding in each country.

Terms	Polarity, arousal, valence	Canada (*n* = 133)	Mexico (*n* = 180)	Spain (*n* = 410)
Alert	Negative, low, displeasure	0.04	0.09	0.09
Assessment	Neutral, low, pleasure	0.21	0.08	0.105
Awareness	Positive, high, pleasure	0.075	0.15	0.21
Extinction	Negative, high, displeasure	0.01	0.11	0.04
Knowledge	Positive, low, pleasure	0.37	0.256	0.21
Risk	Negative, low, displeasure	0.135	0.167	0.16
Threat	Negative, high, displeasure	0.165	0.14	0.18
Emotional content summary				
Polarity	Negative	0.35	0.51	0.47
	Neutral	0.21	0.08	0.10
	Positive	0.44	0.41	0.42
Arousal	Low	0.75	0.59	0.57
	High	0.25	0.41	0.43
Valence	Displeasure	0.35	0.51	0.47
	Pleasure	0.65	0.49	0.53

4.5.2. Relevant terms in newspaper headlines and cluster maps

In total 24, 21 and 22 terms with > 0.3 score in relevance index were retained in the analysis of headlines in Canada, Mexico and Spain respectively (Supplementary table 4.2). The term categories were different among countries (see Figure 4.2), with fewer terms referring to goods in Canada (25%) than in the two other countries (Mexico: 52.4%, Spain: 59%). Considering the environment as a good, the difference among countries was significant (contingency $\chi^2 = 6.11$, 2 d.f., $p = 0.04$, V = 0.2).

Compared to text bodies, headlines exaggerated different term categories in the three countries, as expected in Hypothesis (iv): increasing the proportion of terms about food in Mexico, about health in Spain, and about pollutants in Canada (Figure 4.2). The change in categories between text bodies and headlines was significant for Canada ($\chi^2 = 5.12$, 1 d.f., $p = 0.02$, V = 0.04) and Spain ($\chi^2 = 5.44$, 1 d.f., $p = 0.019$, V = 0.02), but not Mexico.

The differences in the use of terms with emotional content among the three countries were confirmed from the term retained within "Understanding" in headlines (Supplementary table 4.3): "Concern" in Canada (low arousal, negative), "Alert" in Mexico (high arousal, negative), and "Awareness" in Spain (high arousal, positive).

The proportion of terms per category was different in the newspapers and in academic publications about MP psychosocial issues during the same years (Figure 4.2, column at right). As expected in Hypothesis (ii), fewer terms about understanding and more terms about goods were published in newspapers than in academic journals. The differences were statistically significant for all the pairwise comparisons (data not shown).

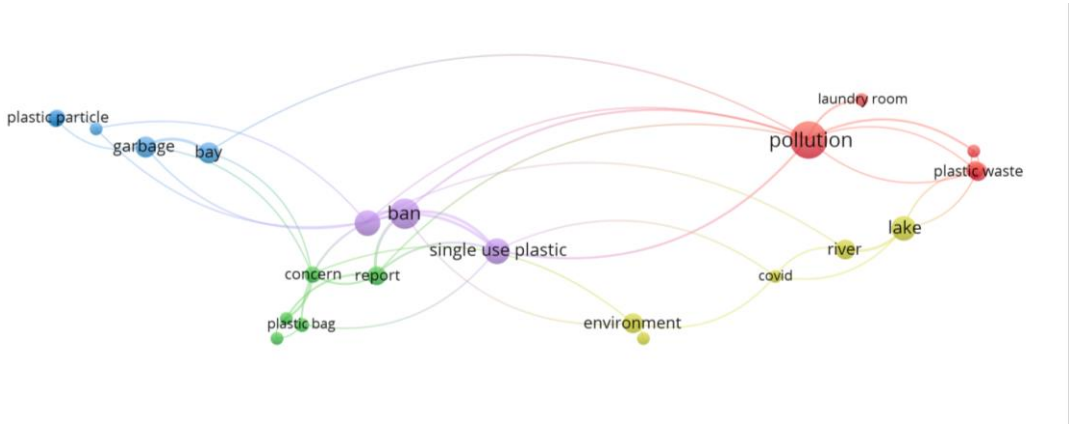
Clustering analysis of headlines confirmed the marked differences between countries revealed from the analysis of term frequency in text bodies and headlines. For the topics, in Canada (Figure 4.3A) solutions like single-use plastic bans (purple cluster) and the understanding of plastic impacts (green cluster) were located close to each other in the middle of the map of terms. The environment and environmental health, in the yellowish cluster, were located between the solutions and the pollution sources that were relatively marginal. The pollution sources (plastic particles, garbage; blue cluster) were linked to solutions and understanding.

In contrast with Canadian headlines, in Mexican headlines (Figure 4.3B) the center was the human and environmental health (red cluster), closely linked with plastic items (purple cluster). Food, water and the term "alert" (green cluster) were next and above in the map. Clusters related with the environment like close habitats (yellowish) and far locations and species (blue cluster) were next to each other and relatively peripheral.

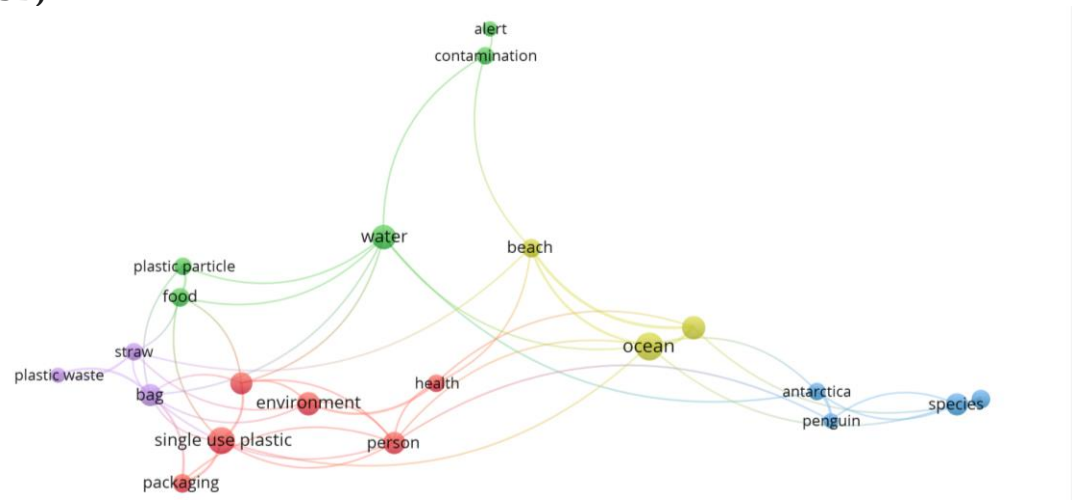
The map for Spain contained mixed clusters (Figure 4.3C). The central red cluster had words related with the environment and the actor "team". Closely linked was the yellowish cluster, again with the environment, environmental health and the term "awareness". Peripheral clusters contained a mixture of actors ("citizens" in the purple cluster, "volunteers" in the red one), understanding ("report" in the green cluster), goods like the fishing resource "anchovy" in the green cluster, and terms related with the environment like "nature" and "world" in the green cluster or "river" and "air" in the blue one.

Figure 4.3. Network map of clusters of relevant words obtained from the headlines of articles published in Canadian (4.3A), Mexican (4.3B) and Spanish (4.3C) newspapers.

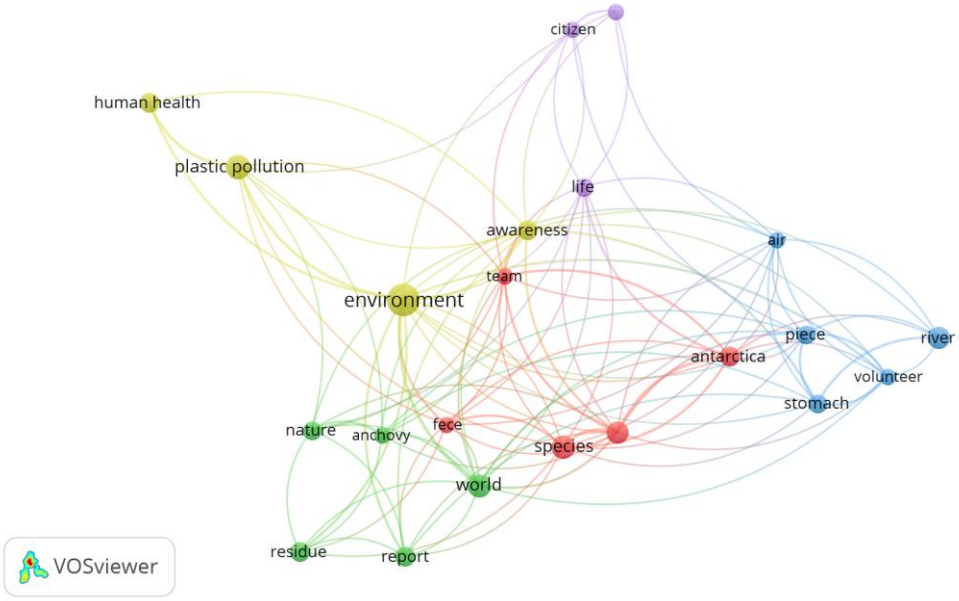
4.3A)



4.3B)



4.3C)



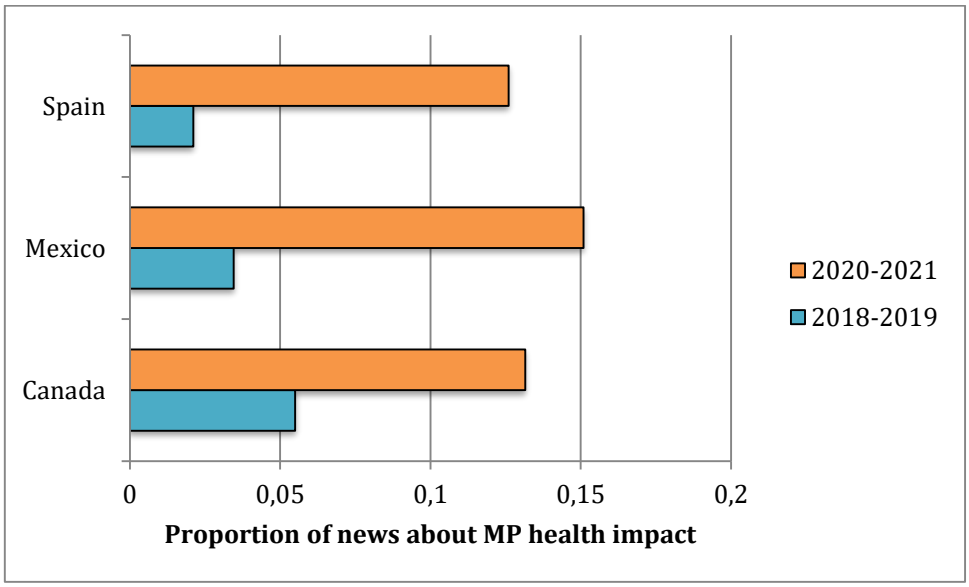
In summary, from the cluster maps constructed from headlines (Figure 4.3) the environment was very important in the three countries, but both food and health were more important in the Mexican than in the Canadian and Spanish maps. In the Canadian map solutions and understanding were central, as were actors in Spain.

4.5.3. Effect of the COVID-19 pandemics in newspaper treatment of MP

As expected in Hypothesis (v), the proportion of articles describing health impact of MP was higher in post than in pre-COVID-19 years in the three countries (Figure 4.4). The difference was significant in Spain with more post- than pre-COVID-19 news about MP focused on health (risk difference = 0.105, z = 2.845 with p = 0.004; odds ratio = 0.149, z = 2.502 with p = 0.012). In Mexican newspapers the difference, although less pronounced, was also significant (risk difference = 0.116, z = 2.14 with p = 0.032; odds ratio = 0.201, z = 1.97 with p = 0.049). In Canada the

difference was not significant (risk difference = 0.077, z = 1.72 with p = 0.08; odds ratio = 0.384, z = 1.676 with p = 0.094).

Figure 4.4. Proportion of news about health impact of microplastics in the studied countries two years before (2018-2019) and during (2020-2021) the COVID-19 pandemics.



4.6. Discussion

This study presents for the first time an analysis of mass media treatment of MP in countries of different culture and development degree: Canada, Mexico and Spain. Results show the importance of the different cultures in the messages that are transmitted to the public, and also suggest a relationship between mass media and policy agendas, as found for climate change (Damsbo-Svendsen, 2022). Supporting Hypothesis (i), in Canada, where microbeads are banned since 2017, newspapers started publishing news about MP impacts at least five years before. According to the relative status of MP bans (earlier in Canada than in Mexico, inexistent in Spain), newspaper publications grew earlier in Canada than in Mexico, and in Mexico than in Spain. Indeed, this observation does not imply a cause (newspapers attention to MP) - effect (a change in public policies about MP) relationship, but politicians are informed about MP from public dissemination of scientific results via mass media, as citizens are (Henderson & Green, 2020; Janouskova et al., 2020; Ojinnaka & Aw, 2020). The responsibility of media shaping public opinion and political action in environmental crises is undeniable (Cottle, 2009): if news media pay much attention to a problem such as MP pollution, likely MP will be introduced in the political agenda.

The effect of the respective culture and development degree was reflected in the different use of terms in the three countries. In the text body, newspapers from highly developed individualistic Canada use more frequently terms related with the environment, and with actors and solutions, than those from the less developed collectivistic Mexico, that use more terms related with the environmental threat (pollution). This would be explained from a concern for the environment itself in developed countries (do Paço et al., 2013) and a focus on its preservation in individualistic countries (Komatsu et al., 2019), while collectivistic countries would be more concerned about environmental threats for their impact in humans and future

generations (Arnocky et al., 2007; Deng et al., 2006). Another aspect that could be explained from cultural differences is the type of terms employed, with more positive or neutral polarity and valence in Canada than in Spain, and in Spain than in Mexico. Individualistic cultures report experiencing more frequently positive than negative emotions (e.g., Kitayama et al., 2000), and this would be reflected in our results. On the other hand, Lim (2016) found that collectivistic Eastern people prefer to experience low arousal emotions. Thus, news containing many terms of high, negative arousal would be uncomfortable for collectivistic Mexicans provoking reactions against MP.

An interesting result that is likely explained by different policies, rather than by from cultural differences, is the higher relative frequency of the term "Government" in Canada than in Mexico, and even more so than in Spain. This order also corresponds to the respective entry in force of microbead bans (inexistent in Spain at the time of this study): first in Canada then in Mexico. Related to this, Canadian newspapers use most frequently the word "Ban" as a solution, while in the other two countries "Recycling" (second in Canada) is first. The three solutions most frequently cited in Spanish newspapers depend on the consumer's behavior: recycling, reducing (consumption) and consuming sustainably. Unlike in Canada, it seems that the responsibility of controlling MP is assigned to consumers, as also happens in Danish newspapers (Ballantine et al., 2021).

Contrary to our expectations (Hypothesis ii), the focus of newspaper articles on food and health MP impacts (versus environmental ones) found by Volker et al. (2020) in the UK and USA was not detected here. In our study, although in both newspaper article bodies and headlines, terms referring to these goods were more frequent than those employed in scientific articles (Figure 3.4), the main focus of the majority of articles analyzed was not health or food, but the environment. In fact, in newspaper text bodies the relative proportion of these goods –environment, food and health- was quite similar to that of the academic works considered by Garcia-Vazquez and Garcia-Ael (2021). The higher environmental focus of newspapers in our study, compared to Volker et al.'s (2020) results, could be because the majority of news about this emerging pollutant was published in the last three years, after Volker et al.'s (2020) study. In these more recent years, the interest in environmental issues has grown worldwide, not only because of increased public attention on climate and sustainability issues (e.g., Damsbo-Svendsen, 2022), but also due to the widely publicized relationship between the advent of COVID-19 pandemics -and other zoonosis- and the environmental deterioration and unsustainable use of planet resources (Mocatta & Hawley, 2020).

The effect of COVID-19 on MP impacts reported in scientific studies (Shen et al., 2021; Tagorti & Kaya, 2022) was also reflected quantitatively in newspapers. As expected in (v), in the last few years, news relating MP with health issues have increased considerably in comparison with pre-COVID-19 times. This increase happened in all three countries, but more in Spain and Mexico, likely due to a combination of their respective cultural traits and development degree. First, Mexico has the lowest development index of the three countries (Canada > Spain > Mexico, Table 1), thus we can understand that health issues are relatively more important there. Canada, with the highest development index, is presumably the least concerned by health. On the other hand, Mexico is the least long-term oriented (Spain > Canada > Mexico; see Table 3.1). Since long-term orientation positively affects health

consciousness (Mahlich et al., 2018; Wang & Chu, 2020), one could expect that Spaniards are more concerned about health than Mexicans.

Similar reasoning may explain the exaggeration of health in Spanish headlines and of food in Mexican ones (Figure 4.2). While health guarantees a good future and is important for long-term oriented persons, food is needed every day. Recent studies show that collectivistic values favor food consumption that can be moderated from future orientation (Tuu et al., 2022). Thus, collectivistic short-term orientation would explain an emphasis on MP impacts on food in Mexico. In Canada, a highly developed country with moderate long-term orientation (Table 4.1), health was moderately emphasized (Figure 4.2), while relevant terms about pollution were clearly more abundant than in headlines than in text bodies. In a country where microbeads are banned, a high concern about MP pollution is logically expected, and newspapers will emphasize this type of message in headlines (Ballantine et al., 2021).

Finally, the legal status of MP bans deserves a comment. Although Rochman et al. (2015) considered that there were sufficient scientific arguments to support a global ban on microbeads, this measure has not been adopted in many countries (Anagnosti et al., 2021). Spain is one of them. The adoption of MP bans in Europe is being compromised by the right to free trade amongst member states; further evidence about the real impact of MP on human health and the environment will be needed to adopt more restrictive measures at the European level (Kentin & Kaarto, 2018). Improving current strategies of science communication, especially the contact between research groups and mass media, would be highly recommended in the three countries because, as seen in Figure 4.2, current scientific foci are not clearly reflected in the analyzed newspapers. This recommendation is even more important in Spain, where single use plastics and MP are not banned yet. This could be a way to achieve the desired goal of fostering exposure science (the contact between stressors and human and ecological receptors) into sustainable policies (Fantke et al., 2022).

CHAPTER 5

STUDY 4: DRIVERS OF SINGLE-USE PLASTIC CONSUMPTION IN DIFFERENT COUNTRIES.

Publication:

Garcia-Vazquez, E., Garcia-Ael, C., Mesa, M.L.C., Dopico, E., & Rodriguez, N. (2022). Enhancing marine citizenship as a strategy to promote the reduction of single-use plastics consumption in different cultures. *Frontiers in Marine Science, 9*, 941694. https://doi.org/10.3389/fmars.2022.941694.

5.1. Abstract

Single-use plastics (SUP) coming from the land represent a large fraction of the marine plastic debris that threatens the ocean biota today and are one of the main causes of microplastic pollution. Consumer behavior is essential to stop the use and improper disposal of SUP, replacing plastic with alternative eco-friendly products. For the evident plastic pollution of beaches and seas, marine citizenship, interpreted as the personal responsibility that individuals take for the oceans, could help to reduce SUP use, and change to sustainable alternatives. Here we studied SUP consumption behaviors in Spain (n = 585) and Mexico (n = 337) using a multivariate multiple regression approach. Different policies and social norms in the two countries were reflected in reduced SUP use in Mexico compared to Spain, and more recycling in Spain than in Mexico. The main reasons for the use of SUP were the lack of alternatives and forgetting reusable goods in the two countries. Feeling responsible for the ocean predicted the intention to use eco-friendly alternatives, while the sea frequentation predicted recycling. Gender, age, and education influenced significantly the willingness to use eco-friendly alternatives. From the results of this study, campaigns promoting awareness through increased ocean literacy and marine citizenship -even in regions far from the sea- could promote reductions in SUP consumption, enhancing the use of sustainable alternatives. Those campaigns could be tailored by country, taking into account local policies and habits, gender, age, and education levels.

5.2. Introduction

5.2.1. How plastics and single-use plastics hamper the Sustainable Development Goals

The United Nations (UN) Sustainable Development Goal SDG#12 is "Ensure sustainable consumption and production patterns", and SDG#14 is "Conserve and sustainably use the oceans, seas, and marine resources for sustainable development" (see the UN Agenda 2030, https://sdgs.un.org/2030agenda, accessed on April 2022). These two objectives are closely connected, because goal 14.1 is the prevention and reduction of marine pollution of all kinds, in particular from land-based activities, and goal 12.5 is to substantially reduce waste generation through prevention, reduction, recycling, and reuse (United Nations, 2015). In this scenario, plastic is perhaps the biggest problem, with trillions of plastic pieces floating at sea (Eriksen et al., 2014). For its dimension, ubiquity, and impacts on biota, marine plastic pollution is considered a planetary boundary threat (Villarrubia-Gómez et al., 2018). Indeed, the majority of plastic debris in the ocean comes from the land (Carroll et al., 2014; Chassignet et al., 2021; Jambeck et al., 2015). Plastic pollution is dramatically harmful to marine life, causing suffocation, entanglement, and high mortality in animals from fish to seabirds to cetaceans (Gall & Thompson, 2015; Li et al., 2016). Moreover, plastics represent a new habitat for invasive species that can be transported fouling on them with the currents, even to remote islands (Rech et al., 2018). It is also the main cause of the emergent microplastic pollution, that in the ocean comes largely from the breakage of plastics improperly disposed of (Wayman & Niemann, 2021).

Single-use plastics (SUP) coming from the land represent a large fraction of the marine plastic debris. The production of SUP has doubled since 2000, and only a small amount of the total SUP produced is currently recycled, while the majority is incinerated or landfilled, then entering the sea through surface runoff (Chen et al., 2021). On a global scale, there are regional differences in the mismanaged plastic

waste produced on coast and ending in ocean water. Chassignet et al. (2021) found that Asian countries, the eastern Mediterranean basin, the Gulf of Guinea, the Atlantic coast of Mexico, the Caribbean Sea, and Central America are plastics emission hotspots, with the southeast of Africa following close, with as many as 10^4-10^5 plastic waste particles beached by 1x1° surface in 2010-2019. In contrast, plastics landed on Atlantic European, North American, Pacific South American, and Australian coasts are in general much fewer –with some exceptions like spots in the Baltic Sea (Chassignet et al., 2021). Many SUP are not necessary or can be easily replaced by reusable goods, like plastic straws, portable cutlery, and others. Some SUP such as plastic bags, that can be substituted by reusable bags, are an important part of current marine pollution and the main focus of many studies about SUP consumption and the efficiency of policies to reduce it in Africa (Adam et al., 2020; Wahinya & Mironga, 2020), America (De Groot et al., 2013; Jakovcevik et al., 2014), Asia (Asih et al., 2020; Vassanadumrongdee et al., 2020), and Europe (Loy & Reese, 2019; Martinho et al, 2017).

5.2.2. Single-use plastics and the R imperatives

Around the world, countries have approached the environmental challenge caused by SUP in different ways. Some have opted to use a top-down approach and, following the advice of international institutions, have adopted institutional policies from the Government (at a national or state scale) to ban different types of SUP, like plastic bags (Muposhi et al., 2022). Other countries have introduced taxes or levies, and many have not started to tackle the problem yet (reviews by Adeyanju et al., 2021; Borg et al., 2022). There are pieces of evidence of regulations based on applying taxes or levies that significantly reduce SUP consumption and promote attitude, perception, and behavior change toward eco-friendly products; however, the effectiveness of those regulations is variable (Adeyanju et al., 2021). Bans are generally well accepted, but not in all countries (Borg et al., 2022). For example, Kenyan consumers complain against current plastic bans that seem to be producing a porous black market (Wahinya & Mironga, 2020).

In the majority of countries, where bans are not applied, SUP are indeed available. Consumer behavior is essential to stop SUP use and improper disposal. Because the 10 most commonly found SUP items on European beaches are more than 50% of the total marine litter in European waters, the EU focuses first on limiting SUP use (Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment). Voluntary actions to reduce SUP usage are necessary to interrupt and prevent the growing SUP pollution (Chen et al., 2021). Beyond the trio Reduce-Reuse-Recycle, the extended 10-R strategies (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover) that are crucial in the circular economy (Kirchherr et al., 2017), may define the framework of individual and societal behaviors desired to solve this problem. The individual refusal of consuming SUP would indeed cut drastically the current accumulation of SUP waste if the behavior were adopted at a large scale, as estimated by Lau et al. (2020) for the scenarios “Reduce” and “Substitute”. Reducing the purchase of SUP, reusing or using them for another purpose, and sorting and disposing of them in the proper trash bin to enable recycling, will no doubt help to reduce SUP waste. However, adopting these behaviors is not always easy. Consumer culture and habits influence individual SUP consumption and may hamper the reduction of SUP consumption (Wiefek et al., 2021). The lack of plastic-free alternatives is a major impediment for many

consumers (Heidbreder et al., 2020). SUP materials could be replaced by eco-friendly alternatives like non-plastic or biodegradable plastics that are generally preferred by consumers over plastic packages (Dilkes-Hoffman et al., 2019a; Gill et al., 2020). Providing plastic-free alternatives is also the preferred intervention for reducing plastic bags in South Africa (O'Brien & Tondhlana, 2019), but they may be difficult to identify. The lack of knowledge about different packaging types is a barrier to the reduction of SUP usage in many countries (Jacobsen et al., 2022); as well as the unawareness of the impacts of plastic (Vimal et al., 2020; Xanthos & Walker, 2017). Knowledge, awareness, and consumer attitudes are indeed important to determine SUP reduction, but other factors are involved too. We revise next the psychosocial theories behind SUP consumption behavior.

5.2.3. Theoretical frameworks to explain SUP consumption behaviors

Like many other issues concerning the environment, in SUP consumption the theoretical frameworks most frequently employed to explain the different consumer behaviors are the Theory of Planned Behavior (Fishbein & Ajzen, 1975) and the Theory of Reasoned Action (Ajzen & Fishbein, 1980). In these models, evaluative beliefs (about the consequences of the actions), and normative beliefs (about what society expects from us, or social norms) together with the motivation to comply with them, will determine respectively attitudes towards a behavior and subjective norms. The combination of those –their relative importance and direction, being favorable or unfavorable towards the pro-environmental action– will influence behavioral intentions, which will be finally transformed into actual behavior (Ajzen & Fishbein, 1980). Sun et al. (2017) found good support for this theory in China, where attitude, perceived social norms, and subjective norms, together with convenience, explain the use of plastic bags. The importance of social norms for SUP reduction has been also highlighted in Canada, where normative (personal and/or injunctive) messages reduced the use of plastic bags more than when only environmental messages were employed (De Groot et al., 2013).

Subsequently, Hines et al. (1986) proposed their Model of Responsible Environmental Behavior based on Ajzen and Fishbein (1980). The model starts from the locus of control (perceived capacity to carry out the action), the individual sense of responsibility, and the attitude, as the personality factors that, together with knowledge and the actual skills to act, will determine the behavioral intention. Finally, if situational factors are favorable, the individual will act pro-environmentally (Hines et al., 1986). Examples like a study in Bali would support this model: social norms did not significantly explain SUP bag consumption; knowledge, environmental concern, and perceived control predicted the use of reusable bags instead (Asih et al., 2020). In a recent review, Jacobsen et al. (2022) reformulated the theoretical SUP framework as the triad of "ability, motivation and opportunity". They identified environmental concerns and social norms as the main motivation factors to reduce SUP consumption.

Building on previous theories that were based principally on reasoning, Kollmus and Agyeman (2002) introduced emotions in their pro-environmental behavior theory, explaining it as the result of complex interactions between internal (knowledge, values and attitudes, feelings, and emotional involvement) and external (infrastructure, culture and politics, economic situation) factors. Feelings of guilt about Nature deterioration (called eco-guilt by some authors) explain, significantly, pro-environmental perceptions and behavior in different studies (Mallett, 2012; Rees

et al., 2014; Wang & Lin, 2018). In an experimental study in Europe and North America, Zwicker et al. (2020) increased the willingness to pay for plastic reduction by manipulating guilt. Here we will introduce emotions to explain the environmental behavior about SUP as well. Since plastic pollution links inextricably SUP consumption with an enormous deterioration of the oceans, we will add marine citizenship feelings in our models.

5.2.4. Marine citizenship as an internal and situational factor to promote SUP reduction

Marine citizenship describes a state where individuals have rights and take personal responsibilities for the oceans (McKinley & Fletcher, 2012). Individuals feeling responsible for the ocean make lifestyle choices to minimize their environmental impact (Fletcher & Potts, 2007). Marine environmental education and personal attachment to the marine environment (including the proximity to the coast, memories of holidays and recreation, historical connections with the marine environment, and others) join the feeling of personal responsibility as key themes for the development of marine citizenship (McKinley & Fletcher, 2010). The plastic pollution of beaches and seas is evident on many coasts worldwide; thus, it seems logical that sea frequentation, the objective and less emotional part of marine citizenship, makes visitors aware of the degradation caused by plastic pollution. An example is German anglers that are concerned about marine litter and consequently prevent fishing gear losses in the Baltic Sea (Lewin et al., 2020). However, on a Greek island where the sea is constantly present, Latinopoulos et al. (2018) did not find a significant effect of informative campaigns about the negative impact of plastics on the willingness of consumers to reduce plastic bags. It seems that the simple presence of the sea around is not sufficient to link SUP use and environmental impact and act accordingly.

Environmental awareness is needed to realize that beaches are littered and act pro-environmentally. Beach visitors adopt sustainable behaviors about litter and litter disposal when they are environmentally aware, as confirmed in Spain, where the level of beach littering is negatively correlated with the awareness of beachgoers about marine litter (Rayon-Viña et al., 2018). If the marine citizens feel responsible for the ocean, we could expect them to behave consciously about SUP because plastic pollution is so evident on beaches and seawater worldwide. Environmental concern is an important driver of SUP reduction behavior (Jacobsen et al., 2022; Walker et al., 2021). The concern about the ocean, feeling personally responsible for the sea –which is key in marine citizenship (Fletcher & Potts, 2007; McKinley & Fletcher, 2012), is perhaps stronger than the mere sea frequentation as a motivation to behave consciously about SUP.

As explained above, pro-environmental behavior is difficult to predict because it is the product of complex interactions between many factors (Kollmus & Agyeman, 2002). Just feeling a marine citizen is probably insufficient to behave responsibly about SUP and plastic litter. Social norms are very important to motivate individuals about SUP reduction (Jacobsen et al., 2022; Jia et al., 2019). Social norms represent what is right, normative, or appropriate in society, and are as important as hedonic and gain goals to motivate plastic mitigation actions (Jia et al., 2019; Steg et al., 2014). If they are not favorable to plastic reduction, social norms may be major obstacles to the rejection of SUP (Heidbreder et al., 2019). There are differences among countries in the social norms about SUP. A survey involving 20.513 adults from 28 countries

revealed that, for example, in Mexico, the level of agreement with banning SUP is as high as 88%, and 84% of citizens think that an international treaty to combat plastic pollution is necessary, while these values are 78% and 68% in Spain, and as low as 37% and 27% in Japan (IPSOS/Plastic Free July 2022). Therefore, we expect differences between countries depending on their social norms.

5.2.5. Socio-demographic determinants of plastic use behavior

Socio-demographic factors like gender, age, education, and income have been related to SUP consumption and littering behavior in many studies. The results, however, may vary greatly among countries and types of sustainable behavior. Older people, and those with a higher level of education and income, litter less and manage waste better than younger people or those with a lower level of education, according to different studies in the USA (Bator et al., 2011), Australia (Slavin et al., 2012) and Spain (Escario et al., 2020). However, younger people consume less SUP than older people in South Africa (O'Brien & Tondhlana, 2019); and high-income people use bottled water more frequently than low-income people in Ghana, where bottled water is perceived as more hygienic and safe (Abrokwah et al., 2021).

Regarding gender, women are more concerned about the impact of SUP in Vietnam (Nguyen et al., 2022) and Australia (Dilkes-Hoffman et al., 2019b), take more actions to prevent beach litter in Tasmania (Slavin et al., 2012), do more litter sorting in Ghana (Owusu et al., 2013), as well as reduce and reuse (but not recycle) more frequently than men in Spain (Escario et al., 2020). In contrast, men act against beach litter more frequently than women in Spain (Rayon-Viña et al., 2018). Interestingly, in a study in Canada, the use of SUP packaging does not seem to vary significantly across ages, genders, and education levels (Walker et al., 2021). From these results, it seems that generalizations are not possible and that socio-demographic factors may influence consumer behavior differently, depending on the country and the circumstances.

Finally, it seems that marine citizenship itself may be also influenced by socio-economic factors. Although women are frequently invisible in many maritime sectors, like fisheries (e.g., Koralagama et al., 2017), the value of the ocean and the activities linked to it seems to be greater for women than for men, as suggested from surveys in Canada (Guest et al., 2015) and Spain (Garcia-Gallego et al., 2021).

5.2.6. Objectives, expectations, and departure hypotheses

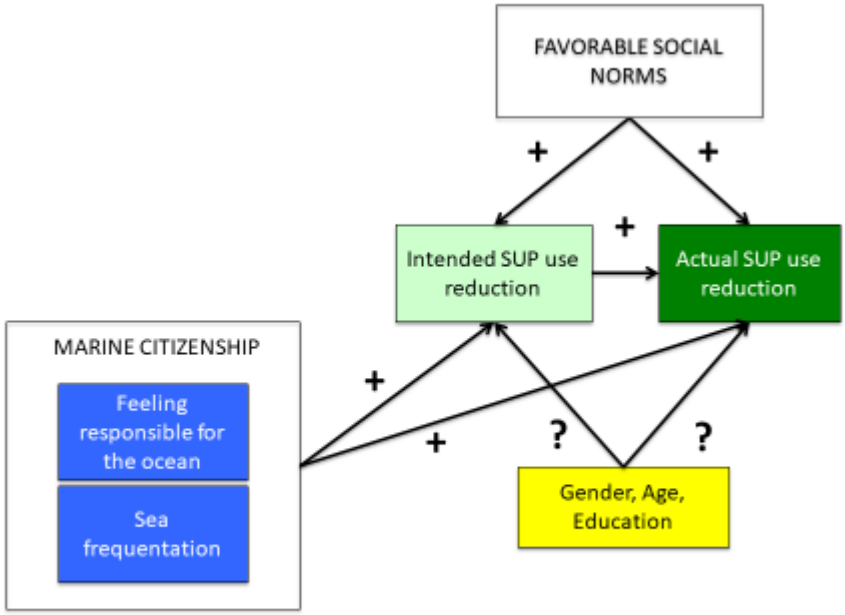
Since there is no consensus about the most effective ways to curb the use of SUP on a global scale, many authors highlight the importance to find new ways to encourage citizens to responsibly reduce SUP consumption (Heidbreder et al., 2019; Adeyaju et al., 2021; Borg et al., 2022), and not only plastic bags, that have been the main focus of studies so far (Adeyanju et al., 2021). Including measures of observed behavior is also recommended (Borg et al., 2022), because in the use of SUP there is a big gap between intention and behavior (Ertz et al., 2017). Since awareness and attitudes have been more studied, Borg et al. (2022) suggest that further studies focus on what to do to motivate consumers to reduce and reuse SUP.

The main objective of the present study is to introduce marine citizenship as a possible way of motivating consumers to responsible SUP consumption behavior. We will explore how two aspects of marine citizenship, sea frequentation and the feeling of responsibility for the ocean, can influence SUP-related behavior in countries with different social norms about SUP consumption: Mexico and Spain, the former being

more favorable to SUP bans than the latter. We will test a model (Figure 1) where marine citizenship, independently of social norms, increases the intention to reduce the consumption of SUP bags and bottles, intention determining further actual reduced SUP consumption. The socio-demographic factors of gender, age, and education would mediate these relationships.

To check the applicability of marine citizenship as an enhancer of other environmental behaviors, we will tackle its effects on litter sorting as well. This practice is widely implemented and generalized in Spain, where around 80% of citizens usually separate glass, paper, and plastic (Escario et al., 2020; Gibovic & Bikfalvi, 2021), while in Mexico the management of solid urban waste is a priority but is still a challenge in many areas (Munoz-Melendez et al., 2021). Researchers propose therein improvements to the best implementation of the federal legal framework for pollution regarding plastics (Lara et al., 2020). Thus, the social norm is expectedly more favorable to litter sorting in Spain than in Mexico.

Figure 5.1. Graphical summary of the model tested in this study. Arrows represent relationships between variables. The sign of the expected relationship is indicated.



From the model summarized in Figure 1 and the references above, our hypotheses were:

i) Marine citizenship i.e., feeling responsible for the ocean and (perhaps) sea frequentation, will predict SUP reduction and the use of eco-friendly alternatives in Mexico and Spain.

ii) Socio-demographic factors like gender, age, and education will mediate between marine citizenship and the intention to reduce SUP. The direction and intensity of the mediation may be different in Mexico and Spain.

iii) From policies and social norms in Mexico and Spain, intended reduction of SUP consumption will be higher in Mexican than in Spanish samples of similar education and age.

iv) Social norms, marine citizenship, and socio-demographic factors will determine litter sorting. For different policies and social norms about recycling, this pro-environmental behavior is expected to be higher in Spain than in Mexico.

5.3. Material and Methods

5.3.1. Ethics statement

This study was approved by the competent Committee of Research Ethics of Asturias Principality with the reference CEImPA:2021.116. The participants were informed about the objective of the study and about their right to withdraw from the study at any moment, and they signed an informed consent document. This study followed the principles of the Declaration of Helsinki and aligns with the European guidelines for ethics in research (European Commission, 2013).

5.3.2. Questionnaire

5.3.2.1. Development of the questionnaire

The tool applied in this study was a questionnaire aimed at gathering information about the following issues: socio-demographic data, marine citizenship, actual use of SUP and reasons for it, and intention to adopt a sustainable use of SUP. Regarding socio-demographic data, we have chosen factors that, from scientific literature, can influence the use of plastics.

Marine citizenship was measured independently from two proxies. One was the actual use of the sea and the other was the feeling of responsibility for the sea, which are key components of this state (McKinley & Fletcher, 2012). Beach frequentation was taken as a proxy for the use of the sea, and the feeling of guilt about harming the sea was taken as a proxy for feeling responsible for the sea as a variant of eco-guilt (Mallett, 2012) specifically referred to the sea.

The actual use of SUP was focused on two common goods of frequent use in the majority of countries: plastic bags and plastic bottles. The following R imperatives were considered: Reducing (SUP use), Reusing (SUP), Repurposing (using SUP for another purpose), Recycling (for this proper SUP disposal and litter sorting is required from the consumer), Refusing (SUP use).

The intention to adopt sustainable behaviors about SUP considered the following R imperatives: Reducing, Recycling (litter sorting), and Replacing (using eco-friendly products).

The questionnaire applied (Table 5.1) was designed based on the questionnaires validated and used by Lee et al. (2014), Rayon-Viña et al. (2018), Deng et al. (2020), and Yoon et al. (2021). The socio-demographic questions and those about the frequency of and reasons for SUP use were adapted from Deng et al. (2020), who applied their questionnaire in Shanghai from 437 respondents. The questions about the intention to behave sustainably regarding plastic consumption and disposal were adapted from the Lee et al. (2014) questionnaire that was applied and validated in South Korea (416 respondents). The question about beach frequentation was taken from Rayon-Viña et al. (2018), who applied it in a survey about marine

litter perception in Spain (201 respondents). Yoon et al. (2021) applied the question about the feeling of being able to harm the marine environment in Korea, China, Japan, and America.

5.3.2.2. Questionnaire structure

The structure of the present questionnaire (Table 5.1) has three blocks: a) socio-demographic data and sea frequentation; b) actual behavior about the use of SUP including frequency of SUP acquisition, reasons for its use, and disposal of the SUP acquired; and c) feeling of responsibility about the ocean and intention of sustainable behavior about plastics, including reduction of plastics use and litter sorting. The questions were translated to Spanish, which is the language of the countries of the study. Details of questionnaire scoring are in Supplementary Table 5.1.

Table 5.1. Questionnaire employed in this study.

Block A: Sociodemographic questions	
Items	**Options**
A1 Gender	Female / Male / Non binary
A2 Age	18-30 / 31-40 / 41-50 / 51-60 / >60
A3 Education level	Junior highschool or lower / Senior highschool / Vocational college / Undergraduate / Graduate or above
A4 Personal income per month ($ or equivalent)	<500 / 500-1000 / 1000-2000 / 2000-3000 / 3000-5000 / >5000
A5 What is/was your field of education	Open answer
A6 How often do you go to the beach/sea?	Every day / Weekly / Monthly / Only in my vacations / Rarely / I do not like the beach
Block B: Single use plastics consumption and disposal. Adapted from Deng et al. (2000)	
B1 How often do you acquire new plastic bag(s) while shopping in supermarkets?	Every time / Usually / Sometimes / Seldom / Never
B2 How often do you buy single use water plastic bottles?	Every time I buy drinking water / Usually / Sometimes / Seldom / Never
B3 Do you sort your garbage before disposing?	Every time / Usually / Sometimes / Seldom / Never
B4 How do you deal with the used plastic bags and bottles?	Dispose as general trash / Dispose in the recycling bin / Reuse / Use for other purposes / I never use this type of goods
Please choose a reason for your acquisition of: B5 plastic bags / B6 bottles	Convenience / Reusability / Affordability / Lightweight / Forgetting reusable goods / Lack of alternatives / Other
Block C: Feeling of guilt (= responsibility) & intended R-behavior. Adapted from Yoon et al. (2021)	
Please rate the following statements	

C1 I feel I could harm the marine ecosystem	Between 1= I totally disagree and 7 = I totally agree
C2 I will reduce plastics use	Between 1= extremely unlikely and 7 = extremely likely
C3 I will sort waste for recycling	Between 1= extremely unlikely and 7 = extremely likely
C4 I will buy eco-friendly products whenever possible	Between 1= extremely unlikely and 7 = extremely likely

5.3.3. Single-use plastic status in the regions studied

The study was conducted in the Mexican State of Hidalgo and Spain. In these countries, there was no SUP ban at the moment of the study. In 2021, in Spain, a plastic bag levy was applied in stores and supermarkets in application of the Royal Decree that regulates the consumption of plastic bags and creates a register of producers (Real Decreto 293/2018, of 18 of May, available at https://www.boe.es/eli/es/rd/2018/05/18/293). Plastic bottles (of water, soda, juice, and other beverages) were commonly available in stores and vending machines. In Mexico, federal laws limiting plastic bags were not in force in 2021, but taxes or bans were applied in various States including Hidalgo. Mexico DC was one of the first largest cities in the world to ban single-use plastic bags, as early as 1 January 2020. Plastic bottles containing water and other beverages were commercialized normally in the two countries in 2021.

5.3.4. Sampling methodology and samples

The questionnaire was self-administered online. The link was given to the participants by email with a brief message stating that the survey was aimed at knowing about plastics consumption, that it was for research use only, anonymous and voluntary, and thanking the respondent for their participation. As explained above, before accessing the questionnaire the participants found an information page about the project, authors, and policy for anonymous data treatment, and had to sign the informed consent.

Two types of respondents were targeted: university students and the general population. University students were chosen because they represent homogeneous samples of a similar education level and age; therefore, intercultural differences can be investigated without complex interferences with the mentioned variables. A general population sample allows for the exploration of the effects of socio-demographic factors like age and education level, that are homogeneous in student samples, thus inferring if the results obtained from students could be similar in other population groups of the same country.

Researchers directly contacted university students in Spain (University of Oviedo and the National University of Distance Education) and Mexico (Autonomous University of Hidalgo State) on their academic emails. Spanish students were asked to contact people outside their university among their acquaintances and pass them a link to the online questionnaire. This snowball sampling, a chain-referral method, is very useful to recruit samples of hard-to-reach communities (Valerio et al., 2016). In the present case, it was chosen because, expectedly, the groups of people contacted by students would belong to a similar (or not very different) culture within each country.

The participants that completed the questionnaire over 90% of the questions (N = 932) are described in Table 5.2. A total of 248 students from Spain and 337 from Mexico, and 347 non-students in Spain, completed more than 90% of the items of the questionnaire. Gender ratios as % of females were 0.74, 0.66 and 0.56 respectively. The numbers of respondents identified as non-binary were respectively 2, 3, and 2. These seven individuals were not included in analyses by gender for their small number. The academic profile, income levels, age, and gender ratios were similar and homogeneous in Mexican and Spanish university students, with a majority of Education students and the great majority of respondents under 30 (Table 5.2). Regarding Spanish non-students, the majority were graduates. The education fields were more or less balanced, between 1% in agriculture to 18% in the field of construction and engineering. The sample was more or less balanced in gender (56% females) and among age groups, the majority (32%) being under 30 (Table 5.2).

Table 5.2. Socio-demographic characteristics of the samples analyzed: students from Mexico and Spain, and non-students from Spain. Education fields follow the International Standard Classification of Education (ISCED, 2011). Results are presented as the proportion of participants in each category, per sample.

		Spain students	Mexico students	Spain non-students
	N	248	337	347
Gender	Females	0.742	0.656	0.565
	Males	0.25	0.335	0.429
	Non binary	0.008	0.009	0.006
Age	Under 30	0.84	0.97	0.32
	30-40	0.09	0.027	0.16
	40-50	0.04	0	0.19
	50-60	0.03	0.003	0.23
	>60	0	0	0.10
Income	0-500	0.84	0.69	0.21
	500-1000	0.06	0.15	0.17
	1000-2000	0.07	0.07	0.41
	2000-3000	0.026	0.04	0.13
	>3000	0.004	0.05	0.08
Education field	Agriculture	0.02	0.04	0.01
	Education	0.60	0.56	0.16
	Engineering, manufacturing & construction	0.02	0.01	0.17
	General programmes	0.02	0.11	0.11
	Health & welfare	0.22	0.04	0.12
	Humanities & arts	0.02	0.02	0.07
	Science	0.05	0.02	0.09
	Services	0.01	0.01	0.10
	Social sciences, business & law	0.04	0.19	0.17
Education level	Junior high school	0	0	0.04
	Senior high school	0	0	0.11

	Vocacional college	0	0	0.25
	Undergraduate	1	1	0.11
	Graduate or above	0	0	0.49

5.3.5. Data analysis and statistics

Differences between samples for the distribution of qualitative variables, i.e., the reasons for the acquisition of SUP or the ways of disposing of SUP bags and bottles, were tested using the contingency chi-square approach and post-hoc tests. The effect size was estimated from Cramer's V, interpreted as weak in the range 0.07-0.21, medium in 0.21-0.35 and large when >0.35 for two degrees of freedom (d.f.) (Sun et al., 2010).

The quantitative variables considered for analysis were: sea frequentation (1-6 scale), feeling responsible for the sea (1-7 scale), intention to reduce SUP (1-7), reduced use of SUP bags and bottles (1-5, the highest value corresponding to no use of those goods), intention to sort litter (1-7), frequency of litter sorting (1-5), age (1-5), education level (1-4), personal income (1-6). Dummy 0-1 was employed for gender (1 female 0 male). For visual representations, the values were transformed to a 1-7 scale.

Normality in datasets was checked using Shapiro-Wilk tests, and homoscedasticity (homogeneity of variances) using Breusch–Pagan's test. When these requisites were confirmed, ANOVA and post-hoc Tukey's pairwise tests were employed to determine differences in behavioral variables (reduced consumption of SUP bags or bottles, litter sorting) between samples. If the requisites were not met Kruskal-Wallis (Hc tie-corrected test) and post-hoc Mann-Whitney tests were employed instead.

Multivariate multiple regression models were run to test the predictive value of independent variables (marine citizenship, socio-demographic factors) on pro-environmental behavior and behavior intention (dependent variables). Sea frequentation and feeling of responsibility for the ocean were treated as two separate independent variables. Other independent variables were the gender dummy, age, education level, and income. This analysis was carried out separately for students and non-students. For students, the only socio-demographic variable considered was the gender dummy, because the samples were homogeneous for the rest of the socio-demographic variables considered. For non-students, all the socio-demographic variables were considered.

To test the mediation role of a variable we followed MacKinnon et al. (2002) and Wuensch (2012). For this, we calculated β = unstandardized regression coefficient for predicting the mediator (a socio-demographic variable) from the independent variable (any component of marine citizenship), and α = partial unstandardized regression coefficient for predicting the pro-environmental behavior or behavior intention from marine citizenship holding constant the socio-demographic variable. These variables were divided by the respective standard errors to calculate Z_β and Z_α scores. For a 0.05 non-directional test the critical value of the statistics $Z_\alpha * Z_\beta$ is 2.18; higher values can be considered significant.

Pairwise correlations between variables were calculated using Pearson's r. Multicollinearity was tested using the variable inflation factor (VIF):

$$VIF_i = 1/(1 - R^2_i)$$

A standard significance threshold of $p < 0.05$ was adopted, applying Bonferroni correction for multiple comparisons whenever relevant. Statistics were carried out with free software PAST version 2.17c.

5.4. Results

The raw results of this study are openly available at the public EU online repository EUDAT with the following DOI: 10.23728/b2share.0b02d78b523544a3a76c621da6c723d2 and permanent PID http://hdl.handle.net/11304/862b380e-da27-495a-85a8-9b2938bcc49c. They include the questionnaire items and the individual answers of the 932 respondents that completed the questionnaire.

5.4.1. SUP consumption behaviors

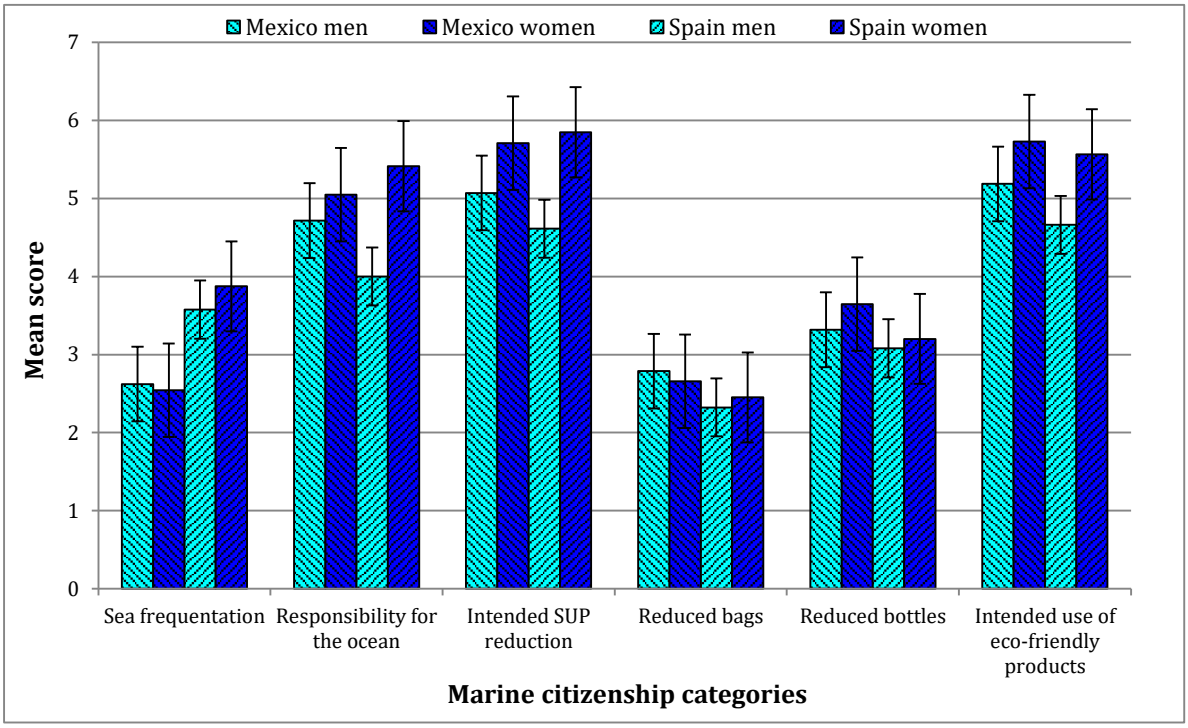
Survey results revealed differences in the two components of marine citizenship considered, and also in SUP consumption, between the samples analyzed (Figure 5.2, Supplementary Table 5.2 for statistics summary). Sea frequentation (Hc = 225, $p << 0.001$ in Kruskal-Wallis test for between-sample differences) was much lower in Mexican students (mean 2.2 in untransformed average, which is between rarely and only in vacations; Figure 5.2A) than in the two Spanish samples (untransformed means of 3.2 and 3.1 respectively, between only in vacations and monthly) that did not differ significantly to each other (Supplementary Table 5.2, post-hoc test not significant). Not frequenting the sea did not mean a lack of responsibility for it in this study. On the contrary, the significant differences between the three samples ($F_{(2,929)} = 5.44$, $p = 0.005$; Supplementary Table 5.2) were due to a lower feeling of responsibility of Spanish non-students (Figure 5.2B) in comparison with the two student samples, despite them visiting the sea significantly more frequently than Mexican students. Mexican and Spanish students did not differ from each other.

The intention to reduce SUP was the highest in Mexican students (Figure 5.2A), then in Spanish students (Figure 5.2A), and finally in Spanish non-students (Figure 5.2B). Kruskal-Wallis test was significant (Hc = 6.87, $p = 0.02$; Supplementary Table 5.2), and post-hoc Mann-Whitney tests revealed significant differences only between the highest Mexican students and the lowest Spanish non-students samples (Supplementary Table 5.2).

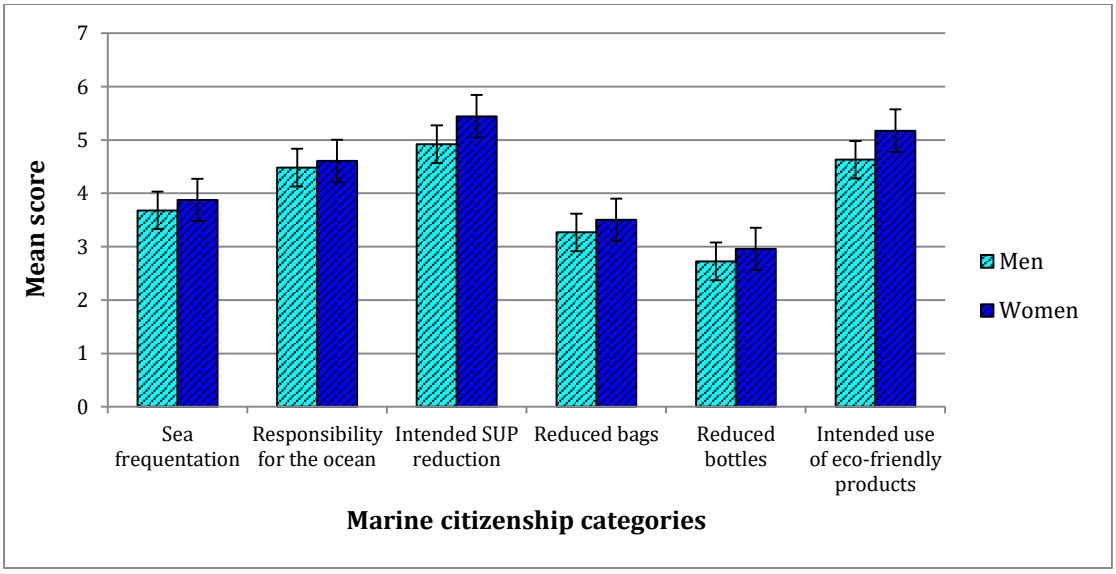
Reduced SUP bag consumption was clearly lower than the intention to reduce SUP, in all three samples. It was significantly different between samples too (Hc = 176, $p << 0.001$), and the three samples differed significantly from each other in post-hoc tests (Supplementary Table 5.2). The highest reduction of SUP bags corresponded to Spanish non-students (Figure 5.2B). In the student samples (Figure 5.2A), consumption of SUP bags was reduced significantly more in Mexican than in Spanish students.

Figure 5.2. Marine citizenship measured from sea frequentation and feeling of responsibility for the ocean, and single-use plastics consumption behavior (as reduced use of these items) in the Mexican and Spanish samples of students (A) and in the Spanish sample of non-students (B) analyzed. Results are presented as mean scores, with standard errors as capped bars.

5.2A)



5.2B)



The consumption of SUP bottles was also significantly different among samples (Hc = 44.2, $p < 0.001$, all post-hoc tests being significant; Supplementary Table 5.2). Mexican students reduced SUP bottle consumption the most (Figure 5.2A), followed by Spanish students (Figure 5.2A), then Spanish non-students (Figure 5.2B).

The last pro-environmental behavior considered in this part, the intention to use eco-friendly products, followed a similar trend to that found for the intention to reduce SUP and the actual reduction of SUP bottles. Mexican students intended to buy more eco-friendly products than Spanish students (Figure 5.2A) and these more than Spanish non-students (Figure 5.2B). The differences were again statistically significant (Hc = 21.77, $p < 0.001$), and like in the case of SUP bottle consumption, all the post-hoc tests were statistically significant (Supplementary Table 5.2).

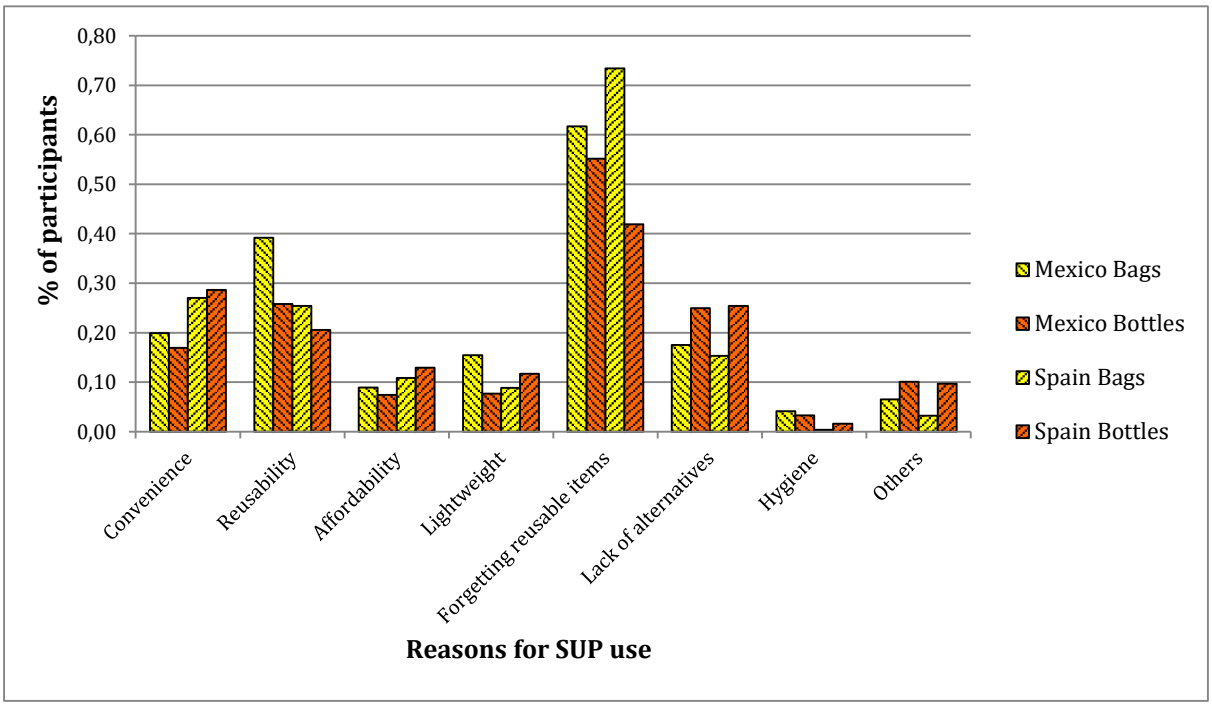
Mean scores were higher for women than for men for the majority of variables measured, in all the samples. This will be analyzed in detail later.

The respondents declared varied reasons for the use of SUP (Figure 5.3), and not the same for plastic bags and bottles. The majority of respondents in the three samples declared to use SUP bags when they forget to bring alternative reusable bags (Figure 5.3); the maximum was in Spanish students, with more than 73% alleging this reason (Figure 5.3A). The second frequent reason was reusability for Mexican students (Figure 5.3A) and convenience for both Spanish students (Figure 5.3A) and non-students (Figure 5.3B). Less than 20% of participants chose any other reason, including typical plastic advantages such as affordability, lightweight, or hygiene. The difference between the three samples was highly significant ($\chi^2 = 51.4$, 14 d.f., $p << 0.001$, Cramer's V = 0.13 indicating a large effect size for 14 d.f.), as it was the difference between Mexican and Spanish students ($\chi^2 = 30.6$, 7 d.f., $p << 0.001$, Cramer's V = 0.18, medium to large effect size for 7 d.f.) and between Mexican students and Spanish non-students ($\chi^2 = 34.6$, 7 d.f., $p << 0.001$, Cramer's V = 0.18). The two Spanish samples were not significantly different indicating similar use of plastic bags ($\chi^2 = 10.4$, 7 d.f., $p = 0.17 > 0.05$ n.s., moderate Cramer's V = 0.10).

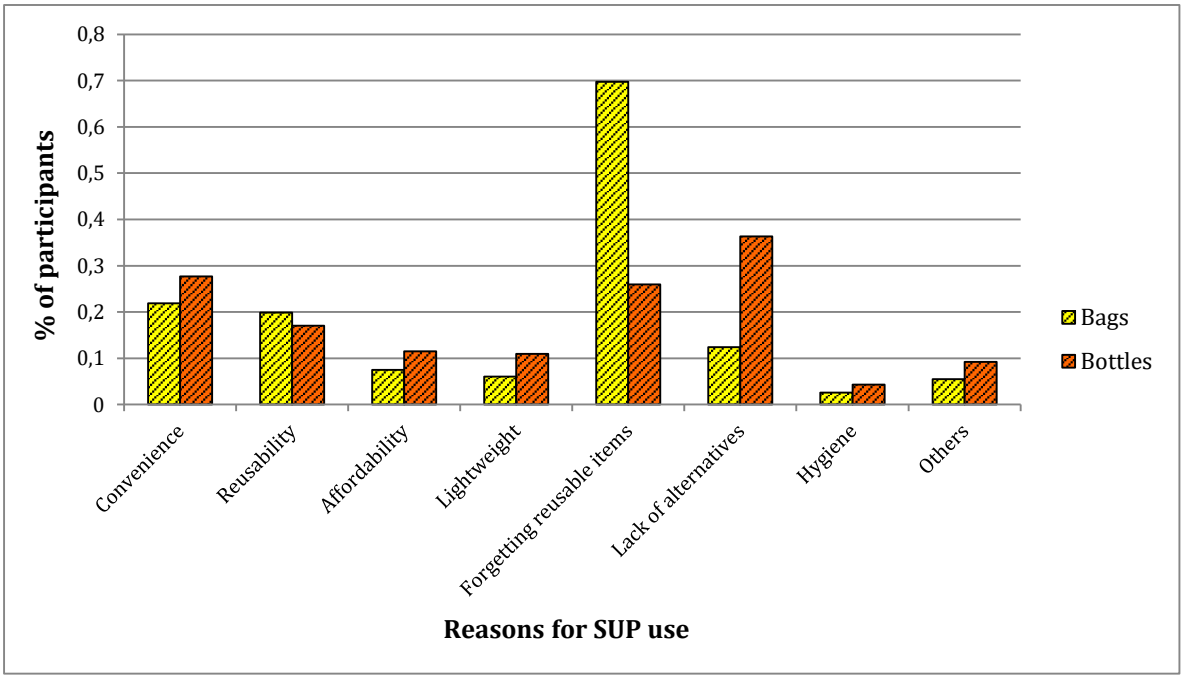
The use of SUP bottles was explained principally by forgetting reusable bottles in the case of student samples, principally in Mexican students (55% of participants), while the reason most frequently alleged by Spanish non-students was the lack of alternatives (Figure 5.3B). As in the case of SUP bags, in Spain, the second frequent reason was convenience (for both students and non-students) while for Mexican students it was reusability again, like for the consumption of plastic bags. The third frequent reason was a lack of alternatives for both Mexican and Spanish students and forgetting reusable goods for Spanish non-students. The rest of the reasons were chosen by less than 20% of participants. The difference among the three samples was statistically significant ($\chi^2 = 73.1$, 14 d.f., $p << 0.001$, large Cramer's V = 0.16), as were the differences between all the pairs of samples in post-hoc tests (data not shown).

Figure 5.3. Reasons for the use of single-use plastics in Mexico and Spain student samples (A) and in the sample of Spanish non-students (B), being plastic advantages, lack of alternatives, forgetting reusable objects or others. Results are presented as the proportion of participants that use SUP for each reason. Note that the sum is >100% in each sample because marking more than one option is possible in these questions.

5.3A)



5.3B)

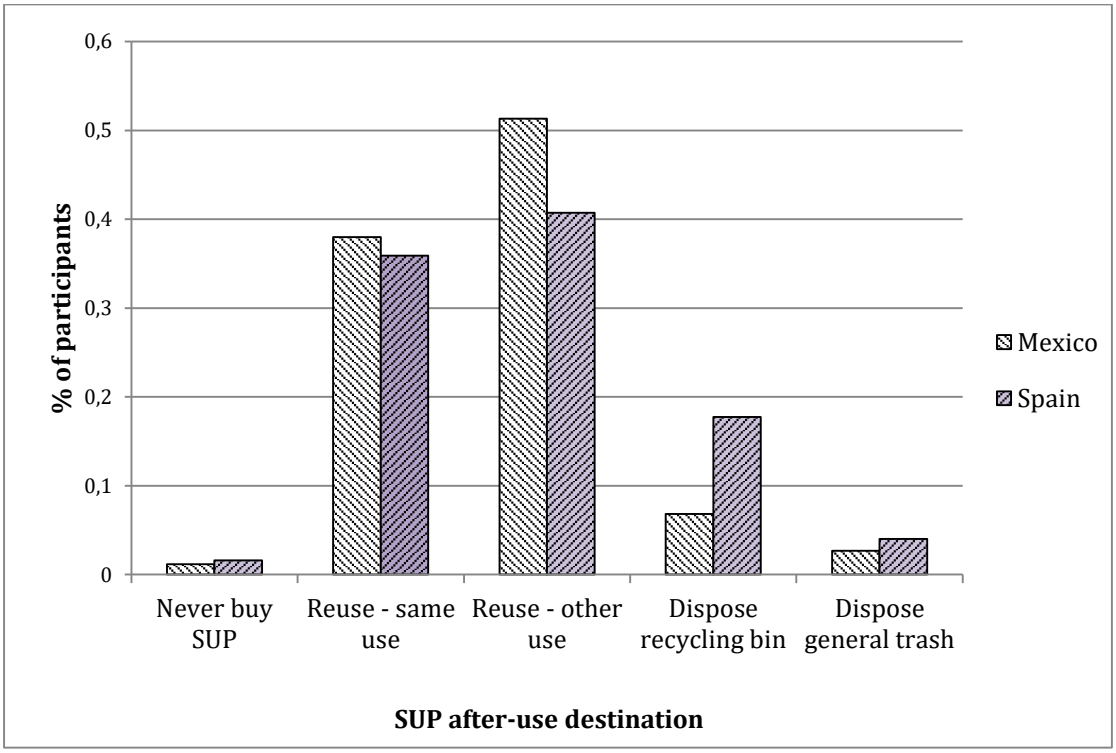


Regarding the after-use fate of the consumed SUP (Figure 5.4A and B), the majority of respondents declared to give SUP bags and bottles a second use, for another or the same purpose, in the three samples. The third choice was to dispose of SUP objects in recycling bins (26%, 18%, and 7% of Spanish non-students, Spanish students, and Mexican students respectively), followed by disposal as general trash (around or less than 5%) and a minority of participants that never use SUP (2% of Spanish samples and 1% of Mexican students).

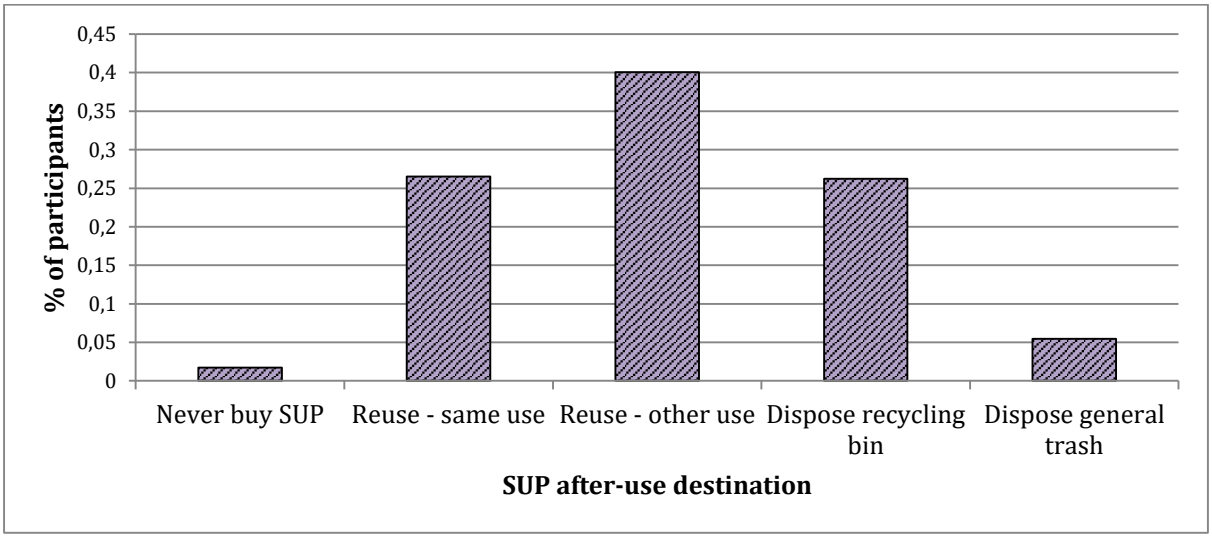
The three samples differed significantly in their SUP disposal behavior (χ^2 = 55.2, 8 d.f., $p << 0.001$, Cramer's V = 0.18 meaning a medium to large effect size for 8 d.f.). However, SUP disposal choices were not significantly different between Spanish students (Figure 5.4A) and non-students (Figure 5.4B) (χ^2 = 9.4, 4 d.f., $p > 0.05$ n.s., weak Cramer's V = 0.12 for 4 d.f.), who tended to reuse these SUP less frequently than Mexican students do (near 90% of Mexican students declared to reuse SUP while this proportion was about 76% and 67% in Spanish students and non-students respectively). Indeed, the difference between Mexican and Spanish students was significant (χ^2 = 19.5, 4 d.f., $p << 0.001$, V = 0.18 medium to large effect size), as well as the difference with Spanish non-students (χ^2 = 53.99, 4 d.f., $p << 0.001$, V = 0.28 large effect size).

Figure 5.4. Declared after-use destination of single-use plastics in Mexico and Spain samples of students (A), and in the Spanish non-student sample (B), presented as the proportion of participants choosing each option.

5.4A)



5.4B)

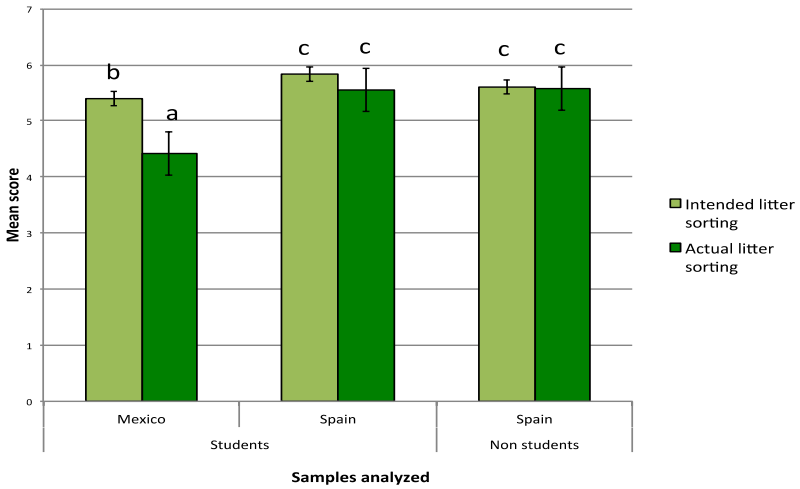


5.4.2. Recycling behavior

Litter sorting –which is required for recycling- is indeed related to plastic mitigation, and from the current recycling policies, we expected it to be higher in Spain than in Mexico. The expectation was confirmed in our samples, where actual litter sorting behavior was more frequent in the two Spanish samples than in Mexican students (Figure 5.5, dark green). The difference between the three samples was highly significant (ANOVA with $F_{(2,929)} = 45.83$, $p < 0.001$). The two Spanish samples did not differ from each other (Tukey's test = 0.0002, $p \approx 1$), the two Spanish samples differed significantly from Mexican students (Tukey's test = 11.37 with $p < 0.001$ in the two comparisons).

The intention to sort waste (Figure 5.5, light green), although generally higher than the actual behavior (especially in Mexican students), followed a similar trend. It was also significantly different among samples (homoscedasticity not accomplished; Hc = 14.36, $p = 0.0008$), being not significantly different between Spanish samples (Mann-Whitney with $p = 0.06 > 0.05$ n.s.), and higher in the two Spanish samples than in Mexican students (Mann-Whitney with $p = 0.002$ and 0.04 for post-hoc comparisons of Mexican students versus Spanish students and non-students, respectively).

Figure 5.5. Mean score of intended and actual litter sorting, indicating the results of the post-hoc tests. Standard error as capped bars.



5.4.3. Effect of marine citizenship and socio-demographic variables on pro-environmental behaviors

The two components of marine citizenship here analyzed were clearly different in their relation to pro-environmental behaviors. In simple pairwise correlations (Supplementary table 5.3), the feeling of responsibility for the sea was correlated significantly with the intended pro-environmental behavior in the three samples. In contrast, sea frequentation was correlated with the actual recycling behavior in the two Spanish samples and with the intention to recycle in Mexican students (Supplementary Table 5.3).

For their different characteristics and significant differences regarding environmental variables, multivariate multiple regression models were run on the three samples separately. Significant multicollinearity could be discarded, because the variable inflation factors were small, from very low V = 1.001 to low V = 1.538.

The results are summarized in Table 3, and the statistical details are provided as supplementary materials. In the sample of Spanish non-students (Supplementary Table 5.4), the model identified three variables that predict significantly intended SUP reduction (Table 5.3): feeling responsibile for the sea, age (the older the more intention to reduce SUP), and gender (females with more intention to reduce SUP). Feeling responsible for the sea also significantly predicted the intention to recycle (together with age but not with gender) and the intention to buy eco-friendly products (together with gender). In all the cases, the level of significance was very high (Supplementary Table 5.4). None of the independent variables examined predicted actual reduction of SUP bags or SUP bottles consumption in this sample. However, the education level (the higher the more) and sea frequentation predicted significantly and positively actual recycling behavior (t = 2.42 with p = 0.016 and 2.16 with p = 0.03 respectively; Supplementary Table 5.4). Personal income did not predict any of the pro-environmental behavior variables considered in this study.

In the Mexican students (Supplementary Table 5.5), the model identified two main predictor variables: gender and feeling responsibility for the sea. As in the Spanish sample of non-students, feeling responsible for the ocean predicted significantly the three behavioral intentions examined (Table 5.3), the three

regressions being highly significant (Supplementary Table 5.5). Gender predicted reduced use of plastic bottles, intention to reduce SUP, and intention to buy ecological products. In addition, sea frequentation predicted the intention to recycle (t = 2.19, p = 0.03; Supplementary Table 5.5).

The model gave similar but not identical results in the samples of Spanish students (Supplementary Table 5.6). Again, the feeling of responsibility for the ocean was a significant predictor of the three pro-environmental behavior intentions (Table 5.3). Sea frequentation predicted the actual recycling behavior, as in Spanish non-students. The main difference was a relatively low prediction value of gender, that in this case predicted significantly only the intention to reduce SUP, t = 3.12 with p = 0.002 (Supplementary Table 5.6, Table 5.3).

Table 5.3. Summary of significant predictor variables of pro-environmental behaviors found from multivariate multiple regression models in the three samples analyzed. Significant predictors are marked with X. Shaded squares, not tested for lack of variation of these parameters in student samples.

		Sea frequentation	Feeling responsible for the sea	Gender	Age	Education	Income
Mexican students	Intention to reduce SUP		X	X			
	Intention to buy eco-friendly		X	X			
	Intention to recycle	X	X				
	Reduced SUP bags						
	Reduced SUP bottles			X			
	Recycling behavior						
Spanish students	Intention to reduce SUP		X	X			
	Intention to buy eco-friendly		X				
	Intention to recycle		X				
	Reduced SUP bags						
	Reduced SUP bottles						
	Recycling behavior	X					
Spanish non-students	Intention to reduce SUP		X	X	X		
	Intention to buy eco-friendly		X	X			
	Intention to recycle		X		X	X	
	Reduced SUP bags						
	Reduced SUP bottles						
	Recycling behavior	X					

From the results above, the three samples had in common gender and the feeling of responsibility as significant predictor variables of pro-environmental behavior intention. Sea frequentation predicted recycling behavior. Gender was also a predictor of actually reduced consumption of SUP bottles. Thus, we focused on these variables to examine the predicted hypothetic model and test mediation effects in the whole sample.

The pairwise correlations between these variables are in Supplementary Table 5.7. Strong positive correlations between the feeling of responsibility for the ocean and intended pro-environmental behaviors, found separately for each sample, were indeed confirmed, as well as positive correlations between pro-environmental

behavior intentions and the corresponding actual behaviors. These correlations were highly significant in all the cases (Supplementary Table 5.7).

After Bonferroni correction, sea frequentation was positively correlated with recycling behavior (r = 0.21, $p << 0.001$) and negatively with reduced SUP bottle consumption (r = -0.13, $p << 0.001$) (Supplementary Table 5.7). This result would suggest a negative effect of sea frequentation in the reduction of SUP, opposite to its effect on recycling.

Gender was significantly and positively correlated with the responsibility for the sea (r = 0.124, $p < 0.001$); logically, it was not associated with sea frequentation (Supplementary Table 7). As in each sample separately, gender was correlated with the three pro-environmental intentions and also with reduced SUP bottle consumption (r = 0.113, $p < 0.001$; Supplementary Table 5.7).

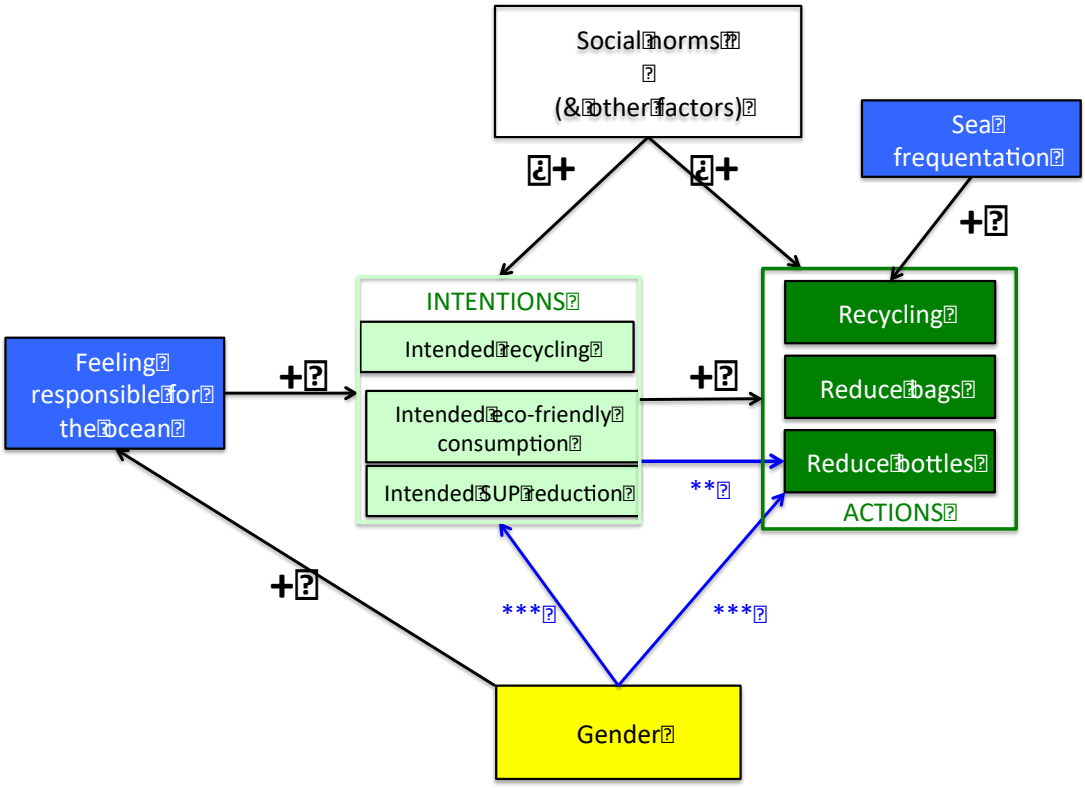
Both intended SUP reduction and intended eco-friendly purchase were significant mediators between gender and reduced bottle consumption (Supplementary Table 5.8, mediations #1 and #2). In other words, females would intend a higher SUP reduction and eco-friendly consumption than males, and those intentions (but not so much being a female) predict a lower consumption of plastic bottles in our study (Supplementary Table 5.8).

These relationships and the differences between countries, representing social norms, can be visually summarized as presented in Figure 5.6. Numerical results are in Supplementary Table 5.9. In the upper part of the figure, pro-environmental social norms (that are different between countries in our study i.e., they would explain, at least partially, the effect of the country) increase significantly both intended and actual behaviors of reducing and recycling SUP. Other factors, like older age and higher education level in Spanish non-students, will also influence sustainable SUP consumption.

In the lower part of Figure 5.6, we see that the actual reduction of SUP bottles is significantly influenced by gender, mediated by the intentions of reducing SUP and purchasing eco-friendly products (Supplementary Table 5.8). Gender does not influence significantly actual and intended recycling behavior in this study.

On the left of Figure 5.6 is represented the emotional component of marine citizenship - feeling responsible for the ocean, which will increase significantly pro-environmental intentions. These intentions will in turn increase the actual reduction and recycling of SUP bags and bottles (Supplementary Table 5.9B). On the right of Figure 5.6, we find sea frequentation, which increases significantly recycling behavior. The negative effect of sea frequentation on the consumption of SUP bottles suggested from pairwise correlations disappears when the effect of the country (social norms) is controlled in a multivariate multiple regression approach (Supplementary Table 5.9).

Figure 5.6. Schematic representation of the main significant relationships between marine citizenship components (sea frequentation and feeling responsible for the ocean, in blue boxes), pro-environmental intentions (light green), and behaviors (dark green) found in this study. Mediation effects are marked with blue arrows and direct effects with black arrows.



5.5. Discussion

The results of this study point to significant, positive relations between two components of marine citizenship, sea frequentation and the feeling of responsibility for the ocean, and pro-environmental behaviors: reduced consumption of SUP bags and bottles and recycling. The feeling of responsibility (in this case perceived personal harm to the ocean) predicted the intention to reduce SUP, buy eco-friendly products, and recycle, while sea frequentation predicted actual recycling behavior. These results would support the Model of Responsible Environmental Behavior (Hines et al., 1986) because personal responsibility is a key trait of environmentally responsible behavior intention.

The results supported only partially Hypothesis I, because only behavior intentions about SUP were predicted from the responsibility for the sea, not actual behaviors. In their work about the perception of the ocean's microplastics, Yoon et al. (2021) found that feelings of guilt about the ocean predicted pro-environmental behavior intentions. Their result was similar to ours in the sense that the question employed here to measure the feeling of responsibility for the ocean (one of the items

employed by Yoon et al., 2021, to measure feelings of guilt) also predicted behavior intentions.

Our study went further exploring the actual behavior. In clear contrast with the emotional component of marine citizenship, the sea frequentation seems to act more directly on behaviors rather than on behavioral intention. Going frequently to the sea predicted recycling behavior in our study, which, together with significantly predicted recycling behavior from responsibility for the sea, supported Hypothesis IV. Pro-environmental litter treatment has been associated with beachgoers' awareness in other studies (Rayon-Viña et al., 2018; Slavin et al., 2012); our results would point in the same direction in samples from Mexico and Spain.

Counter-intuitively, sea frequentation was correlated with *higher* consumption of SUP bottles when the whole sample was analyzed (Supplementary Table 5.5). This effect could be explained by the difference between countries, since Spanish students frequented more the sea (which is circumstantial) *and* consumed more plastic bottles than Mexican students. Hypothesis III predicted differences between countries for SUP consumption intention and SUP consumption. It was fully confirmed in our study, where Mexican students clearly adopted more pro-environmentally behaviors than surveyed Spanish students of a similar age. The effect of social norms, here deduced from different policies (bans and levies in Mexico, only levies in Spain) and opinions about SUP bans (IPSOS/Plastic Free July 2022), would explain this difference and support other studies where social norms are essential for SUP consumption behavior (Jacobsen et al., 2022; Jia et al., 2019). Heidbreder et al. (2019) highlighted social norms and habits as major barriers to reducing SUP consumption; these barriers would be higher in Spain than in Mexico.

Social norms and habits would also explain the difference between Mexican and Spanish respondents regarding recycling behavior. In this case, as expected in Hypothesis IV, recycling was significantly more frequent in Spain than in Mexico. Again, the different recycling habits and policies in Spain (Escario et al., 2020; Gibovic & Bikfalvi, 2021) and Mexico (Munoz-Melendez et al., 2021) would explain the observed differences.

Supporting Hypothesis II, several demographic factors predicted pro-environmental behavior. Gender influenced significantly many variables in this study, and the direction was the same in the Mexican and Spanish samples. The first variable of importance where gender was significant was the own feeling of responsibility for the ocean, which was higher in women than in men. This result supported other studies like Guest et al. (2015) and Garcia-Gallego et al. (2021), where women valued the ocean more than men. Moreover, in all our samples being a woman predicts more environmental-friendly behaviors, mediated or not by behavior intentions, than being a man. This happened in Mexico and in Spain. Our results would support those obtained regarding more pro-environmental behaviors about plastics in women, found in Spain (Escario et al., 2020) and in other countries (Dilkes-Hoffman et al., 2019b; Nguyen et al., 2022; Owusu et al., 2013; Slavin et al., 2012). This result contradicted Rayon-Viña et al. (2018) that found men to take more action against litter. In the Spanish sample of non-students, older age and a higher education level also significantly predicted SUP consumption and recycling. Our results were compatible with many other studies (e.g., Bator et al., 2011; Escario et al., 2020; Slavin et al., 2012), although not with the negligible influence of socio-demographic factors found

by Walker et al. (2021) in Canada, or with more reduced use of SUP in younger South Africans (O'Brien & Tondhlana, 2019).

It is important to remark that the vast majority of the respondents in this study adhered to an R strategy for SUP after-use, although only a few opted to Refuse SUP bags and bottles. The main reasons declared by respondents were forgetting reusable goods and reusability, plus lack of alternatives in the case of SUP bottles (see Figure 5.3). These are quite commonly alleged causes of SUP use. In their review, Heidbreder et al. (2019) reported studies where the main reason to use plastic bags is forgetting one's own reusable bag. This was the main reason declared by Spanish respondents in our study too. In Mexico, instead, reusability was the first cause of SUP use. Like in the Mexican sample, reusability –together with convenience and easy availability- was one of the main reasons for the use of plastic bags in South Africa (O'Brien & Tondhlana, 2019). A lack of alternatives has also been reported as an important barrier to SUP reduction (Heidbreder et al., 2020).

An interesting difference between students and non-students for plastic bottle consumption was found. Non-students used fewer plastic bottles than students did (Figure 5.2). Habits that are the main barriers to the individual reduction of SUP consumption (Wiefek et al., 2021), could explain this difference. Young people are high consumers of bottled water (e.g., Jovarauskaitė et al., 2020), and would consequently purchase more SUP bottles than older people do when they forget (or do not find) reusable ones. On the other hand, being a female was a predictor of reduced use of plastic bottles, mediated significantly by the intention to act sustainably (both intended SUP reduction and use of eco-friendly alternatives). This is consistent with differences between genders in bottled water consumption drivers found from Hong Kong and Macau (Qian, 2018) to Brazil (Pacheco et al., 2018), and indeed supports the presence of gender in the list of factors intervening in sustainable behaviors.

This study has some limitations. One is that in our survey we did not test essential elements of Ajzen and Fishbein (1980) and Kollmus and Agyeman (2002) models, like knowledge and attitudes about SUP. Our intention was to explore the possible use of marine citizenship for encouraging consumers to reduce SUP, not to create a new model. Another possible limitation was that the online survey used a single model of a questionnaire, not balancing the blocks and questions. Finding the items that measure behavior intention right after the question about the personal concern for the ocean (in Block C; see Table 5.1) perhaps elicited somewhat biased responses towards behavior intentions. However, this possible limitation does not affect the comparison between Mexico and Spain, the results related to actual behavior, or the predictive value of independent variables.

5.6. Applications to SUP control

The main novelty of this study was to put together components related to marine citizenship and R behaviors related to plastics like reducing SUP consumption and recycling. Other authors like Yoon et al. (2021) found that the specific reference to the harms caused by plastics to the ocean (microplastics in their study) was useful to increase the intention to adopt pro-environmental behaviors. Enhancing marine awareness has been proposed in other studies as a way to improve serious problems of coastal littering and biopollution in Spain (Rayon-Viña et al., 2022). The concern about the ocean could be employed in public awareness campaigns to convince

citizens to refuse SUP, something that is still infrequent in the Mexican and Spanish groups analyzed in this study.

Ocean Literacy is essential here. Ocean Literacy could be defined as the individual understanding of how the ocean affects people and how people affect the ocean (Costa & Caldeira, 2018; Worm et al., 2021). It is included within the Sustainable Development Goal 14 -*Life below water*- in the United Nations Decade of Ocean Sciences for Sustainable Development 2021-2030 (UNESCO-IOC, 2021). In educational settings, ocean literacy research has revealed that students' understanding of the ocean is significantly correlated with their environmental attitudes (Lin et al, 2020). Although ocean literacy is not usually included among the curricular contents or in the usual teaching practices –ocean literacy programs being often considered non-formal education (Ferreira et al., 2021)– its inclusion in all educational contexts should be a priority (Worm et al., 2021). We support these views for a conscious, informed concern about the ocean in the population.

The concern about the ocean was also significantly related to the intention to buy eco-friendly products. Plastic-free alternatives are preferred for plastic mitigation in many studies (Dilkes-Hoffman et al., 2019a; O'Brien & Tondhlana, 2019; Gill et al., 2020). The use of ecological alternatives could also be encouraged by using marine citizenship as a central topic in informative campaigns. It has to be recalled that the concern for the sea does not depend on the proximity to it. These two variables were not correlated in our study, and the value assigned to ocean resources and diversity is not different in coastal and inland regions in other studies (Garcia-Gallego et al., 2021). Thus, campaigns based on ocean conservation are likely similarly effective in regions located at different distances from the sea.

Public awareness through education programs reduces marine debris creating a sense of environmental responsibility (Bravo et al., 2009); thus, civic public education could be another strategy to reduce SUP use where bans are not well accepted or are still far from implementation (Borg et al., 2022; Wahinya & Mironga, 2020). Civic education addresses competences such as civic and political knowledge and skills, sense of responsibility, and citizen active participation (Schulz et al., 2018). Although in citizenship education teachers' beliefs may prioritize some of its content (Reichert & Torney-Purta, 2019), civic learning promotes capacities to gather and analyze available information to make informed decisions. Taking SDG 14 as a reference (which seeks to prevent and reduce marine pollution of all kinds), civic public education can provide the basic concepts, procedures, and attitudes needed to reduce SUP, regardless of the legislative initiatives that a government may adopt. From our results, including the emotional components of marine citizenship in public education campaigns could improve their effect regarding not only SUP reduction but also other R-behaviors like recycling. These behavioral changes would surely reduce the current plastic and microplastic pollution in the ocean.

5.7. Conclusions

This study showed that feeling responsible for the ocean was a significant predictor of the intention to reduce SUP consumption in Mexican and Spanish student samples, and in Spanish non-students. A higher SUP reduction in Mexican than in Spanish students was consistent with stricter SUP bans (thus social norms favorable to SUP reduction) in Mexico than in Spain. Gender was a significant mediator between the intention to reduce SUP consumption, the intention to buy eco-friendly

products, and the actual consumption of plastic bottles. Sea frequentation did not influence significantly SUP consumption in this study.

Recycling behavior (specifically litter sorting) was more frequent in Spanish than in Mexican students and was significantly predicted by sea frequentation, and recycling intention was predicted from the feeling of responsibility for the ocean.

Age and education also influenced pro-environmental behaviors in Spanish non-students, older age promoting the intention to reduce SUP and recycling, and a higher level of education intended recycling.

The results of this study suggest that enhancing the emotional components of marine citizenship could promote the reduction of SUP consumption and increase alternative eco-friendly choices. This effect would be obtained even in populations living apart from the sea or visiting the coast infrequently.

CHAPTER 6

STUDY 5: THE RELATIVE IMPORTANCE OF AWARENESS AND LEGISLATION IN PRO-ENVIRONMENTAL BEHAVIORS REGARDING MICROPLASTICS

See publication in Annex II:

Garcia-Vazquez, E., Garcia-Ael, C., Mesa, M.L.C., Rodriguez, N., & Dopico, E. (2023). Greater willingness to reduce microplastics consumption in Mexico than in Spain supports the importance of legislation on the use of plastics. *Frontiers in Psychology*, *13*, 1027336. https://doi.org/10.3389/fpsyg.2022.1027336.

6.1. Abstract

Introduction: Microplastics (MP) threaten all organisms worldwide. MP are produced directly as microbeads in cosmetics and hygiene products, or indirectly from breakage of larger plastics. The control of MP requires consumers' engagement to refuse products containing microbeads.
Methods: We conducted a survey on 572 university students from Mexico and Spain, two countries where microbeads are not banned yet. More strict laws for plastic control are enforced in Mexico than in Spain.
Results: Controlling for age and education, despite knowing less about MP, Mexicans checked for microbeads on product labels more frequently than Spaniards, and desired to reduce MP consumption more. A stronger correlation between individual awareness and willingness of MP control was found for Mexican than for Spanish students.
Discussion: Perhaps more strict legislation against plastics creates an environment favorable to MP control. Unclear statement of microbeads on labels was the main reason for not checking microbead contents; environmental education and a stricter control of plastics and MP were identified as necessary policy changes in the two countries. Corporation engagement on clearer product labeling is also suggested.

Key words: Pro-environmental behavior; Consumer awareness; Mexico; Microplastics; Microplastics risk awareness; Spain.

6.2. Introduction

The problem of microplastics (MP hereafter) has a global dimension. Water and MP are the sole elements common to all the ecosystems today, life occurring worldwide with the presence of small plastics, from the atmosphere to the poles and from highest mountains to abyssal plains (Chen et al., 2020; Mishra et al., 2021; Peng et al., 2017). MP are defined as plastics smaller than 5mm (Thompson et al., 2004), and represent an emerging pollutant which removal from the ecosystems is not easy; efficient cleanup technology is being investigated yet (Magalhães et al., 2020; Vivekanand et al., 2021).

MP are harmful for all the organisms studied to date. MP cause adverse effects of different nature, including physiological and neurological damage, growth retardation, oxidative damage and others (Barboza et al., 2020; Gola et al., 2021). From fish consumption only, humans take around 840 MP/year (Barboza et al., 2020). We also breathe a considerable amount of MP, especially microfibers (Gasperi et al., 2018); around 48,000 MP particles per day are taken by inhalation (Wieland et al., 2022). MP are made up of toxic monomers able to cause inflammation, alteration of immune function, reproductive toxicity, mutagenesis, and cancer in humans (Gasperi et al., 2018; Prata et al., 2020).

Primary MP (i.e., those that are produced of this small size) are included in many products like cosmetics and personal care products, cleaning agents, paint and coatings (Van Wezel et al., 2016). Microbeads are added in cosmetics for exfoliation, cleansing face and body and cleaning teeth in toothpaste, both in rinse-off and leave-on products (Anagnosti et al., 2021). For their known risk and accumulation in the environment and organisms (Rochman et al., 2015), non-degradable plastic microbeads contained in personal care products are banned from eleven countries in North America, Asia, Europe, and in New Zealand, while bans are proposed in other

six countries, and microbeads are being phased out in three more (Anagnosti et al., 2021; Dauvergne, 2018; Lam et al., 2018). This implies that in the majority of countries microbead bans are not applied yet. Moreover, other types of primary MP like polyester glitters coated with metal, widely employed in cosmetics, textiles and household applications, are generally overlooked (Yurtsever, 2019), not being explicitly considered in the bans. Industrial abrasives or laundry detergents that contribute significantly to MP pollution (e.g., Rochman et al., 2019) are also excluded from bans so far.

In a global market dominated by supply and demand laws, citizens could help to stop MP production taking individual actions as consumers; especially in the countries where microbead bans are not planned yet. Evidently, checking regularly microbeads from product labels to avoid the purchase of MP-bearing goods is the first, easy behavior that can be adopted, using instead eco-friendly MP-free products. In this study, we will explore if current pro-environmental legislation may promote these simple behaviors in societies where MP bans are not implemented yet. Policy and legislation have been described as effective top-down means to promote pro-environmental practices in different countries and cultures. Examples are the reduction of poisoning practices promoted by the awareness of environmental legislation in Kenia (Didarali et al., 2022); the pro-environmental engagement of Australian employees following corporate pro-environmental policies (Albrecht et al., 2021); or the stronger environmental concern of citizens living in cities with more sustainability policies in China (Liu et al., 2018).

Country policies about the use of plastics may help the residents of that country to develop a generic attitude towards plastic derivatives like MP. Legislation regarding plastic consumption differs greatly between countries (Adeyanju et al., 2021). For example, in Mexico there are total bans to single-use plastics in force in several states since 2020. Mexico DC was a world's pioneer megacity in the adoption of bans to this type of plastics, starting with legislation in 2019 to ban to plastic bags and products with MP starting in 2020, extended to all single-use plastics in January of 2021 (Decreto Congreso Ciudad de Mexico I Legislatura, of 25 of June of 2019; available online at http://legismex.mty.itesm.mx/estados/ley-df/DF-L-ResSol-Ref2019_06.pdf). In contrast, only levies are applied in Spain, specifically to plastic bags (Royal Decree 293/2018 of 18 of May of 2018; https://www.boe.es/eli/es/rd/2018/05/18/293). The level of support of plastic bans and international treaties against plastic pollution is higher in Mexico than in Spain (IPSOS/Plastic Free July, 2022). Here we will investigate if this is extended to MP.

6.3. Literature review

Knowledge about MP is the first step needed for people to become aware of MP impacts and –may be– change their behavior. The majority of consumers are not conscious of acquiring products with MP (Henderson & Green, 2020; Ojinnaka & Aw, 2020). Yan et al. (2020) found that people are unaware of MP due to their invisibility. Moreover, for their small size MP are not easily detected in the environment, thus they were only relatively recently considered an emerging contaminant (Katsnelson, 2015). Since they are difficult to see with the naked eye, most people are aware of them thanks to media (Henderson & Green, 2020). Someone has to tell us they exist and are ubiquitous; then we know. For this reason, knowledge occupies a central position in the psychosocial landscape of behaviors involved in MP emissions

(reviewed by Garcia-Vazquez & Garcia-Ael, 2021). According to the Theory of Reasoned Action where knowledge is essential to change behavior intention then behavior (Ajzen & Fishbein, 1980), the information about MP increases awareness and intention of behavior change in different studies (Cammalieri et al., 2020; Chang, 2015).

Although in other issues like climate change the perception of risk predisposes to act pro-environmentally (e.g., Bradley et al., 2020), Deng et al. (2020) showed in their study in China that the knowledge alone (not the concern) was sufficient to increase the intention to reduce MP emissions. Those that are aware of MP will tend to reduce them, perhaps because they are clearly unnatural (Anderson et al., 2016). Even being unaware of their risks, we understand that we should not eat, breath, live with MP. However, this issue is not totally clear because in Korea the risk perception (influenced by knowledge) is what affects significantly pro-environmental behavior intention towards MP (Yoon et al., 2021). Similarly, the concern determined the willingness to pay for MP control in Norway (Abate et al., 2020). More studies will be needed to make this aspect clear.

Another factor influencing behaviors about MP is the country or culture. For example, for similar levels of knowledge the willingness to pay for MP-free products is higher in Portugal than in Germany and Norway (Misund et al., 2020). However, there are very few studies comparing attitudes towards MP among countries. The country coverage of the knowledge about awareness and behavior towards MP is still scarce, with some regions clearly understudied like African and American countries (Garcia-Vazquez & Garcia-Ael, 2021).

Finally, socio-demographic factors like age, gender and education have shown to influence attitudes and behavior towards MP, although the direction of the differences is not always clear. Educated people are more aware about MP (Ojinnaka & Aw, 2020). Gender and age would have contradictory effects depending on the study. Abate et al. (2020) found Norwegian males to be less concerned about MP but would pay more to control them. In contrast, Chinese women would have stronger intention to reduce MP emissions than males (Deng et al., 2020). Younger people are more aware of MP in Belgium (Herweyers et al., 2020) but less in Portugal (Soares et al., 2021). More studies are needed to understand how socio-demographic factors influence consumers' relation with MP.

6.4. Objectives and research hypotheses

The specific objective of this study was to determine the differences between Mexico and Spain on the behavior and behavioral intentions about MP. Mexico applies stricter plastics control measures than Spain, but specific laws for MP are not in force therein yet. Research hypotheses were:

1) From the difference between Mexico and Spain for the treatment of plastics, we expect that Mexicans avoid products with MP (Hypothesis i) and will to control MP (Hypothesis ii) more than Spaniards.
2) Living in an environment that makes Mexicans more conscious of plastics issues, the correlation between individual awareness and willingness to control MP will be stronger in Mexico than in Spain (Hypothesis iii).

6.5. Methods

6.5.1. Ethics considerations

The competent Committee of Research Ethics of Asturias Principality approved this study with the reference CEImPA:2021.116. The participants were informed about the objective of the study, about their right to withdraw from the study in any moment and signed an informed consent. We followed the principles of the Declaration of Helsinki adhering to the European code of conduct for research integrity (All European Academies, 2017).

6.5.2. Questionnaire employed

The questionnaire gathered information about the following issues: socio-demographic data, knowledge of MP, awareness of MP risk (environmental, social, for health), actual behavior of checking MP from commercial labels, intended behavior of reducing the consumption of products with MP and using eco-friendly products instead. We have collected socio-demographic data for factors that, from scientific literature, can influence knowledge and attitudes towards MP: age, gender and education level. To identify possible methods to control MP, we asked for the main reasons to not check microbeads from commercial products, and for policies to control MP.

The questionnaire was based on those created by Deng et al. (2020) and Yoon et al. (2021) that were tested and validated in China, and China, Japan, Korea and USA, respectively. Questions about socio-demographic issues, MP knowledge and policies for MP control were adapted from Deng et al. (2020) and those about MP risk awareness and behavioral intention from Yoon et al. (2021).

The first version of this questionnaire was examined from a panel of experts (N = 6). All their suggestions were introduced in the definitive questionnaire that was re-examined and approved by the expert panel.

The questions here analyzed, and their respective coding and scoring are summarized in the Supplementary table 6.1. Section A is devoted to socio-demographic information. It includes country (laws about plastics are different in Mexico and Spain), gender, age, and education level (A1 to A4). Section B contains two questions about the actual behavior of checking MP (how frequent is, and reasons for not checking MP). The section C refers to knowledge about MP. C1 is the self-declared knowledge of MP. In the items C3, C4 and C5 (multiple answers possible) all the answers offered are true from the science (e.g., Gasperi et al., 2020; Prata et al., 2020; Rochman et al., 2015, 2019; Van Wezel et al., 2016). Thus, the actual knowledge about MP sources (C3), environmental sinks or sites of MP accumulation (C4), and ways of MP to enter the human body (C5) is the sum of the respective items marked (marked = 1, unmarked = 0). C6 asks about the policies considered good to control MP. Finally, Section D contains a 7-point scale with three items measuring the awareness about MP risks (D1 to D3), and the intentions to adopt pro-environmental behaviors (D4 and D5 here).

The questionnaire was prepared in two versions (English and Spanish) and administered according to the mother tongue of the participants (Spanish). The English version of the questionnaire was produced by blind back-translation (Jackson et al., 1983).

6.5.3. Sampling methodology

The questionnaire was created in a digital version for self-administration online. Researchers passed the link to university students by email with a brief message about the aim of the study (research about microplastics perceptions), its anonymous nature and use exclusively for research. The respondents were thanked for their participation and asked politely to pass the link to the online questionnaire to their acquaintances (snowball methodology, see Valerio et al., 2016). Before accessing the questionnaire, the participants were informed about the project, authors and policy for anonymous data treatment, and signed the informed consent.

The time estimated to fill in the questionnaire is 10-15 minutes. Incomplete questionnaires with < 80% items filled were not taken into account.

6.5.4. Data analysis

6.5.4.1. Variable scoring

Different types of variables were considered in this study. Socio-demographic variables (section A) were scored as explained in Supplementary table 6.1. For correlation and regression analysis dummies were employed for gender (0 = man, 1 = woman) and country (1 = Mexico, 0 = Spain, accordingly to the strictness of laws against plastics). In these analyses, non-binary respondents were excluded for their small number.

For the declared knowledge (item C.1, "Have you heard about MP before this survey?") a dummy was employed (0 = no, 1 = yes). The actual knowledge about MP was measured as the mean number of the sources (items C.3), sinks (items C.4) and ways of MP to enter the human body (items C.5) identified.

In the section D, 1 is extremely unlikely/total disagreement and 7 extremely likely/total agreement. The MP risk awareness was the mean of the social, health and environmental risks perceived (items D.1, D.2 and D.3 respectively).

6.5.4.2. Statistics

The Content Validity Index (CVI; proportion of experts rating an item as quite relevant or relevant; values over 0.78 are considered acceptable) was calculated to assess the validity of the questionnaire (Polit et al., 2007). The reliability of the variable measures based of combined items in this survey was determined employing Cronbach's α, considered to be a good reliability index (Raykov & Marcoulides, 2017). Cronbach's α values over or around 0.8 are considered sufficient to meet reliability for applied research (Cho, 2020).

Measurement Invariance (MI) is generally checked to assess the cross-cultural equivalency of latent psychological variables measured from a number of items, often through Confirmatory Factor Analysis –CFA- (Milfont, & Fischer, 2010; Hu et al., 2019). As described above, in the present study the majority of variables are measured directly from only one item of the questionnaire i.e., are not latent variables, thus the model cannot be tested using CFA. Although factorial analysis was not possible, as a proxy we explored MI focusing on the only variables measured from several items: MP risk awareness (three items). Mardia's multivariate kurtosis and skewness tests did not meet the normality assumption for this variable; Doornik and Hansen test was $Ep = 376.3$ with $p << 0.001$. Given the lack of multivariate normality we employed RMSEA and χ^2/df as measures of model fit, and did partial invariance testing (e.g., Steenkamp, & Baumgartner, 1998) using JASP (JASP Team, 2022).

To test Hypotheses i) and ii) we employed multiple multivariate regression analysis to determine which independent variables predicted significantly the dependent ones that were behavior and intended behavior in this study. Bonferroni correction was applied for multiple comparisons. For pairwise comparisons, differences in means were estimated from *t*- tests, and differences between medians from Mann-Whitney tests. To test Hypothesis iii) ANOVA analysis was employed to compare Mexican and Spanish regressions of MP reduction willingness on awareness, positive interaction representing a higher slope in the Mexican sample.

Differences between samples for the distribution of qualitative variables (obstacles to MP control, policies suggested) were tested employing contingency statistics: Chi-square of contingency, with Cramer's V to estimate size effect. The free software PAST version 4.09 (Hammer et al., 2001) was employed.

6.6. Results

6.6.1. Questionnaire and survey data

The CVI obtained for this questionnaire from the expert panel was 0.96, showing a high experts' agreement about the content validity of the final version. The raw results of the survey (n = 956 after removing questionnaires with <80% items filled in) are publicly available in Mendeley Data repository with DOI 10.17632/9bzcw5yrpx.1 (Garcia-Vazquez et al., 2022).

For this study we chose only university students due to the significant effect of the education level as a predictor of pro-environmental behavior intention about MP found in previous studies (Ojinnaka & Aw, 2020), and the influence of age (Herweyers et al., 2020; Soares et al., 2021). In our samples the factors "education level" and "age" were controlled, being very similar across groups (Table 6.1). The number of students that completed the questionnaire was n = 254 from Spain and n = 318 from Mexico.

Table 6.1. Descriptive data of the samples analyzed in this survey indicating the number of respondents, mean age (SD in parenthesis), mean education level (4 is undergraduate and 5 is graduate or above), and proportion of women and non-binary, by country. Score of individualism/collectivism (higher values, individualism) assigned to each country in Hofstede et al. (2010).

	Mexico	Spain
N	318	254
% females	66.7	72.8
% non binary	0.9	0.4
Mean education	3.8 (SD 0.55)	3.91 (SD 0.63)
Age range	18-31	18-33
Individualism	30	51

The internal consistency was measured from Cronbach's α values, being 0.94 for the items measuring MP risk awareness. This value is > 0.80 thus the construct can be considered reliable (Cho, 2020). The analysis of this latent variable gave very

robust MI (RMSEA = 0.001; χ^2 /df = 0.095). The χ^2 /df values was < 5; from this and reliable Cronbach's values we decided to keep all the items in this construct.

6.6.2. Effect of the country on the behavior about microplastics

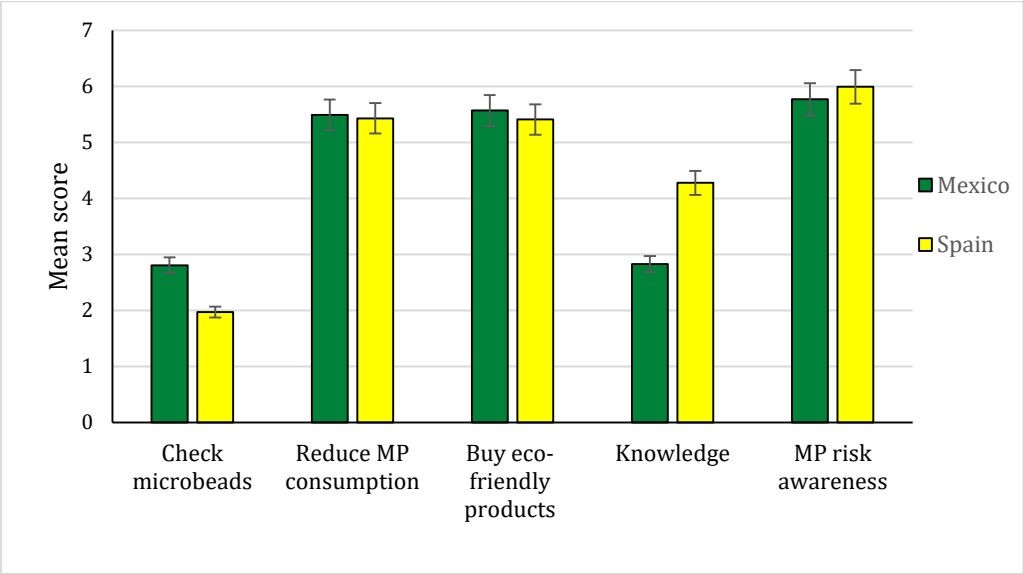
Means and standard deviations of the variables measured per country are in the Supplementary table 6.3. A 35.3% of Mexican students declared to have heard about MP before this survey, a proportion significantly lower than the 67.9% of Spanish students with self-declared knowledge of MP (χ^2 = 74, 1 d.f., p <<0.001). Pairwise correlations between the willingness to control MP consumption and buy eco-friendly products were positively and significantly correlated in Mexico (Table 6.2, below diagonal) and Spain (Table 6.2, above diagonal); in contrast, the behavior of checking microbeads was not positively correlated with any of the other variables, being negatively correlated with the intention to control MP consumption in Mexico (Table 6.2). Controlling the rest of variables in multivariate multiple regression, gender did not predict significantly the dependent variables ($F_{3,565}$ = 1.67, p = 0.17 > 0.05, n.s.).

Table 6.2. Pairwise correlations between the behavioral variables analyzed in Mexican (below diagonal) and Spanish (above diagonal) student samples. Pearson's r values and their significance are given, as * = p < 0.05 and *** p < 0.001

	Check microbeads	Reduce MP consumption	Buy eco-friendly products
Check microbeads		-0.018 n.s.	0.089 n.s.
Reduce MP consumption	-0.123 *		0.827 ***
Buy eco-friendly products	-0.081 n.s.	0.889 ***	

Confirming Hypotheses i) and ii), the country was a highly significant predictor of the three dependent variables ($F_{3,565}$ = 17.61, p << 0.001). Student samples from Mexico and Spain were significantly different to each other for the three behavioral variables examined (Figure 6.1). Mexican students checked microbeads more frequently (t = 7.33, p < 0.001), intended to reduce MP consumption (t = 2.29, p = 0.02) and to buy eco-friendly products more than Spanish students (t = 2.99, p = 0.003), even if they knew less about MP than Spaniards (t = -9.7, p < 0.001 for the actual knowledge, consistently with the self-declared knowledge in each country). The country did not predict significantly MP risk awareness in this analysis (t = -1.58, p = 0.12, n.s.).

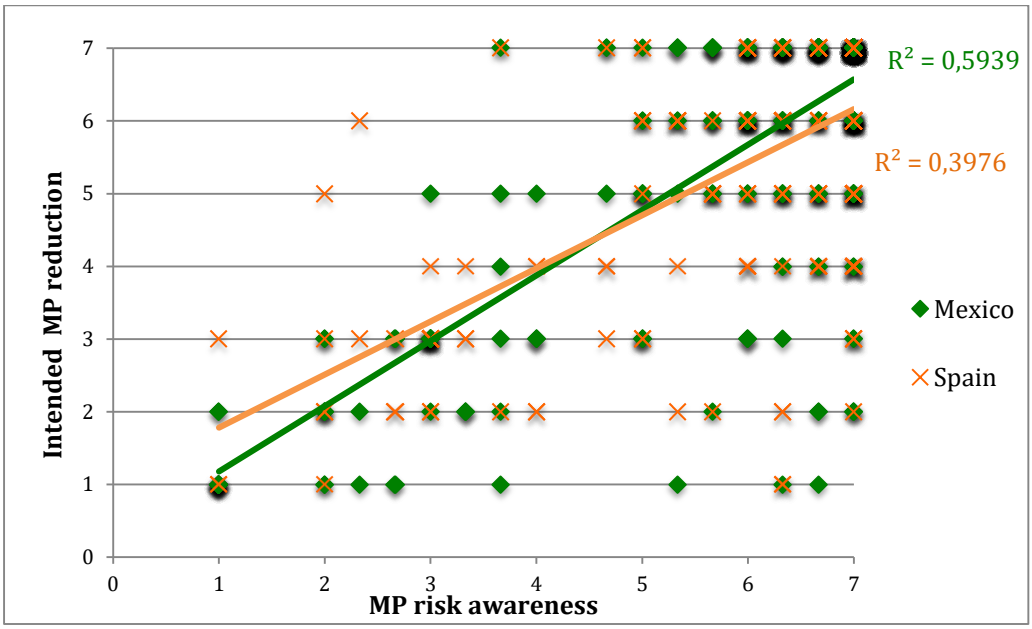
Figure 6.1. Means for Mexican and Spanish students of the variables "Checking microbeads", "Intention to reduce microplastics consumption", "Intention to buy eco-friendly products", "Knowledge about microplastics", and "Microplastics risk awareness". Standard errors as capped bars.



6.6.3. Awareness and knowledge as predictors of MP control behavior in Mexico and Spain

Results showed that controlling for the other variables MP risk awareness predicted significantly the intention to control MP consumption in Mexico and Spain (regressions with equations $y = 0.899x + 0.278$ and $y = 0.73 + 1.05$ with $r^2 = 0.59$ and 0.39, respectively; both with $p < 0.001$). Confirming Hypothesis iii), the correlation with risk awareness was higher in Mexico than in Spain (Figure 6.2), with a significant interaction [country] x [awareness] ($F = 23.88$, $p = 0.003$). This means that the awareness matters for both countries but matters more for Mexico.

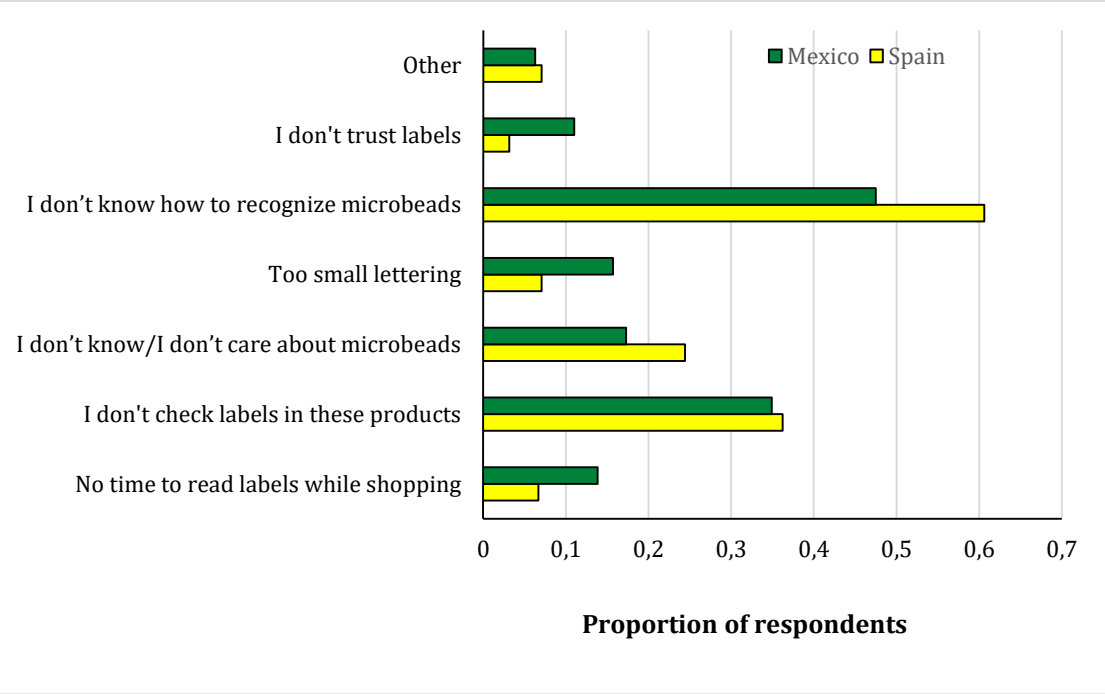
Figure 6.2. Graph plotting the willingness to reduce microplastics (MP) consumption on awareness of microplastics risk scores. The regression lines are presented: in green for Mexico and in orange for Spain, with their r^2 values in the same colors.



6.6.4. Obstacles and recommended policies for MP control

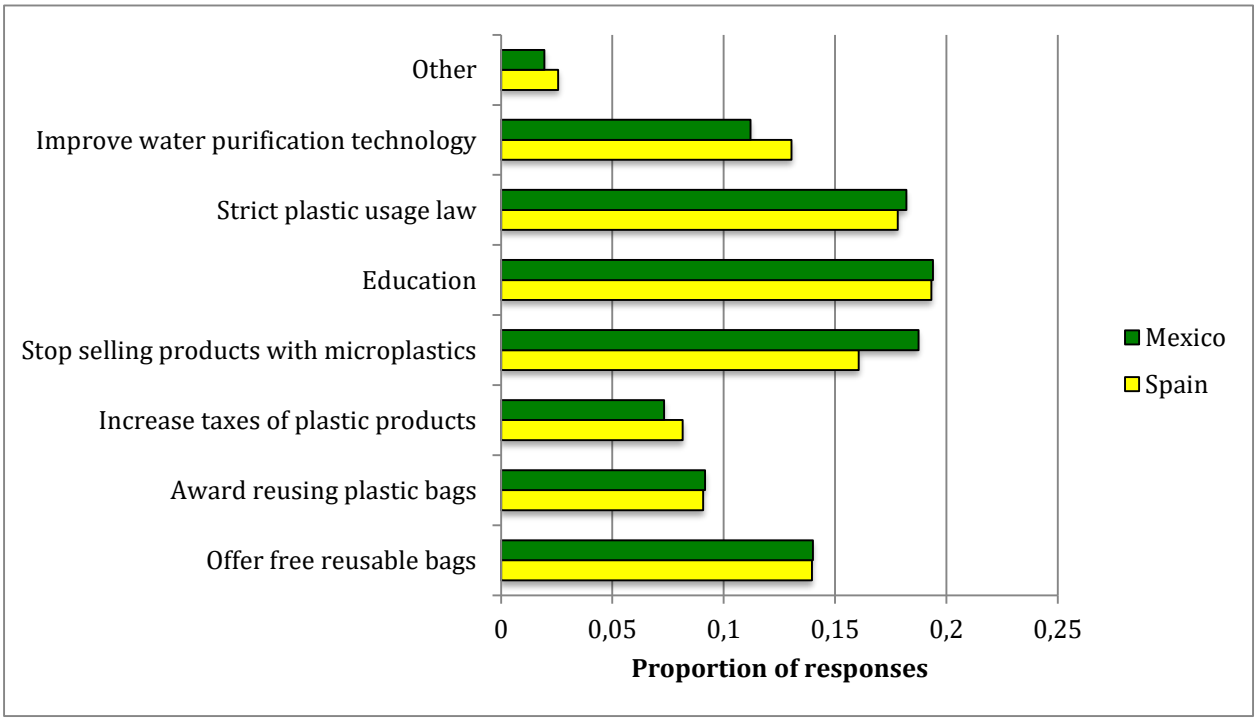
The reasons for not checking microbeads and the recommended policies for the control of MP were also analyzed in the two groups of students. Significant differences between Mexican and Spanish students were found for the reasons alleged for not checking microbeads (χ^2 = 38.7, 7 d.f., $p < 0.001$, Cramer's V of 0.20), being mistrust of labels, small lettering and no time to read labels while shopping more frequent in Mexico, while not caring about microbeads and not being able to identify microbeads in the labels were more frequent in Spain (Figure 6.3). Not recognizing microbeads from labels was the most frequent reason in the two countries.

Figure 6.3. Reasons stated for not checking microbeads in the student groups surveyed in this study. Results are presented as proportion of respondents that alleged each reason, by country. The total sum is higher than 100% because multiple answers were allowed.



Regarding the recommended policies (Figure 6.4), there were no significant differences between the two countries (χ^2 = 4.28, 7 d.f., p = 0.75 and Cramer's V = 0.05). Note that in Figure 6.4 the sum of percentages is 100% because, although multiple answers were allowed in these questions, we considered the proportion of responses choosing each policy over the total number of responses by country. Policies recommended by the respondents for a better control of MP were education first (more than 60% of respondents chose that option, above 15% of the total number of responses), then stricter laws for plastic usage and stop selling products with MP – which is the same as microbead bans, chosen by more than 50% of the respondents and also above 15% of the total responses. Next options were offering free reusable bags and improving technology for water treatment (more than 30% of respondents). Other options like taxes or awards for reusing plastic bags were less supported (Figure 6.4).

Figure 6.4. Policies recommended for the control of microplastics in the samples surveyed in this study. Results are presented as the proportion of responses choosing each policy, by country.



6.7. Discussion

6.7.1. General discussion of the results

The results of this study provide novel evidences of cross-cultural differences and similarities regarding MP. For the first time, psychosocial drivers of behaviors and behavioral intentions towards MP were determined in Mexico and Spain, two countries without microbead bans at a national level (Anagnosti et al., 2021) but with different legislations about plastics. The level of declared and actual knowledge of MP was clearly superior in Spain than in Mexico, where participants were able to identify less sources, sinks and ways of MP to enter the human body than Spanish ones. Notwithstanding it, Mexicans checked microbeads more often than Spaniards did, confirming Hypothesis i). They also declared a higher willingness to control MP according to Hypothesis ii). The paradox of a low knowledge but a high concern and willingness to consume controlling MP is not so rare in the specific field of MP. In USA, Chang (2015) found that the majority of respondents in their study were unaware of MP in personal care products, but after being informed they refused to consume those products again. Belgians would intend to buy preventive devices against microfibers when they perceive an environmental benefit, even knowing little about MP (Herweyers et al., 2020). In our study, the majority of those students hearing about MP for the first time when filling the questionnaire were from Mexico, a country already sensitized about plastics. It seems logical that they will be concerned and will reject MP, because they are clearly unnatural and unnecessary (Anderson et al., 2016).

Unlike knowledge, the awareness of risks seemed to play a more important role in our study for determining behavioral intentions. Abate et al. (2020) in Norway and Yoon et al. (2021) in Korea found that the concern predicted significantly the intention to support MP control measures. Our results would align with these authors because the awareness of MP risks predicted significantly the willingness to control MP in the two countries. Moreover, the association between awareness and MP control intention was stronger in Mexico than in Spain, according to Hypothesis iii) and to their respective support of plastic bans (IPSOS/Plastic Free July 2022).

The difference between countries in the practice and intention of pro-environmental behaviors could be attributed to stricter legislation about plastics in Mexico, probably combined with other cultural traits, as we will explain below. Although individuals may exhibit oppositional behavior when top-down approaches to environmental conservation are applied (Linklater et al., 2019; Schultz, 2011), it did not seem to happen in our study. Mexicans are probably more conscious of the plastic threat than Spaniards, as it is reflected in their high support of plastic bans and international treaties (IPSOS/Plastic Free July 2022). Checking for plastics (microbeads or any other type) in personal care products sounds logical in a country where the legislation is stricter, and the society is favorable to plastic bans.

Together with a higher conscience of plastic threats, the collectivism in Mexico could also contribute to explain the differences between countries. In the same vein as Sreen et al. (2018), it is possible that people in Mexico showcase more of collectivistic values by making decisions regarding MP. In collectivist cultures, consumers tend to engage in behaviors that benefit society as a whole, even though these behaviors may be detrimental to them. For example, Moon et al. (2008) found that consumers in a collectivist culture were willing to pay more for products beneficial to society as a whole than those in an individualistic culture.

Although the results of this study supported the departure hypotheses, they would not fit exactly into the classic Theory of Reasoned Action that is generally applied to pro-environmental behaviors (Ajzen & Fishbein, 1980), where behavioral intention comes first and predicts actual behavior. In our study it seems that the adoption of a real behavior against MP pollution is disconnected from the behavior intention, as suggested from non-significant or even negative correlations of checking microbeads with the intentions to reduce the consumption of goods with MP in the two countries. However, this cannot be confirmed from the results of the present study in which the intention to check microbeads, although implicit in the two behavioral intentions, was not explicitly posed. Those who check microbeads from labels (expectedly to avoid products with them) do not need to declare further intentions to do it. A similar result was found by Kim et al. (2018) in the University of Washington regarding initiatives to reduce carbon emissions: for those that were already taking pro-environmental actions, campaigns to increase environmental awareness had small effect. Likewise, in their study with university students Camallieri et al. (2020) found that informing about MP increased significantly the awareness in less formed students, but not so much in those that were already aware of the problem.

6.7.2. Limitations of the research

This study has some limitations. First, it was the use of only one questionnaire version with the items in a given order (Dopico et al., 2022). Although the results were solidly supported from statistics, the doubt about a possible effect of locating the

questions about behaviour intentions at the end of the questionnaire will persist. Perhaps they influenced somewhat the answers of those unaware of MP; however, if they were located at the beginning it is possible that they would be unable to answer them.

From the methodological point of view a limitation of this study was the absence of Measurement Invariance (MI) calculations for the whole model. Partial invariance testing may be not enough to ensure accurate cross-culture comparisons (Steinmetz, 2018). In the present study the majority of variables are measured from only one item; CFA is based on latent variables measured from multiple items; thus, it is not the best choice for our data. At least for the latent variable of MP risk awareness the model was apparently acceptable, but the rest of variables were not analyzed. Although Welzel et al. (2021) have shown cases of cultural constructs with high predictive power that do not fit MI, the results may be thus taken with caution.

Finally, this study was conducted in university student samples. Although this served to control for age and education, there is a doubt about the representativeness of these samples of the whole society in the two countries. More studies in general population samples are necessary to confirm the results of this work.

6.8. Practical implications

This study has implications in several aspects of the societal support to MP control. From the low level of knowledge about MP found in some sectors of this study, measures to increase the public knowledge about this environmental problem should be taken. In our study the most frequently proposed solution was education (Figure 6.4). Similar recommendations (e.g., Charitou et al., 2021) are identified by the vast majority of authors working on MP and could be considered commonplaces for different collectives and societies. They could be implemented at different levels. Focusing on European countries, Charitou et al. (2021) recommended more publicity on European directives, and also the integration of the topic of MP in formal education programs. We fully adhere to this recommendation and expand it to other countries like Mexico. Increasing the knowledge about MP is especially important in countries without microbeads bans because it will contribute not only to reduce MP pollution but also to reduce the demand of this type of products. Information campaigns should be tailored by country and working sectors.

Implementing microbeads bans and legal measures against plastics are urgent, and these two policies have been proposed from the majority of respondents in our study (Figure 6.4). Top-down approaches could be adopted to control MP; they may reinforce attitudes favorable to plastic control thus increase the intention to consume MP-free products.

Here we found significant differences between countries for awareness of MP and actual behavior to control them. Those countries have different social norms and cultures. As suggested by Garcia-Vazquez and Garcia-Ael (2021) and other authors (Ojinnaka & Aw, 2020), the intercultural aspects of the psychosocial issues involved in MP mitigation should be further explored to be able to better determine the scale of intervention designs.

Some actions to change consumption habits regarding MP could be very simple, warranting at the same time the respect of consumer's rights. Here the corporations that sell hygiene and cosmetics products have an important role. They

could facilitate informed consumer's choice with simple practicalities, like ensuring that the information about MP on product labels is visible and understandable. In our study, main obstacles for checking MP from labels were unclear or illegible information about microbeads in the labels (Figure 6.3). A clearer, legible display of microbead content should appear in labels of personal care products and cleansers.

6.9. Conclusions

1) In this study, Mexican respondents checked for microbeads in personal care products more than Spanish respondents did and manifested a higher willingness to control MP consumption. Individual awareness was more strongly correlated with the willingness to control MP in Mexico than in Spain. Legislation favorable to the control of plastic reduction in Mexico, together with a collectivist culture, could explain this.

2) One of the main barriers to checking MP in this study was unclear information on the labels. Corporations should improve label's design of personal care products and cleaners.

3) The participants in this study identified education as the main policy to be applied for the control of MP, so campaigns to inform about the products that contain MP and the widespread accumulation of this pollutant in the ecosystems and organisms could help to reduce MP consumption. MP pollution risks and their global impact could be also introduced in the information campaigns to increase their effect.

CHAPTER 7

STUDY 6: NUDGES TO PROMOTE R-BEHAVIORS FOR THE CONTROL OF MICROPLASTICS

See publication in Annex II:

Garcia-Vazquez, E., Garcia-Ael, C., Ardura, A., Rodriguez, N., & Dopico, E. (2023). Towards a plastic-less planet. Gender and individual responsibility predict the effect of imagery nudges about marine (micro)plastic pollution on R-behavior intentions. *Marine Pollution Bulletin*, *193*, 115157. https://doi.org/10.1016/j.marpolbul.2023.115157.

7.1. Abstract

Emerging microplastics (MP) pollution is one of the biggest threats for the oceans today. Consumers could reduce MP pollution adopting R-behaviors such as reducing consumption of plastic, refusing products with MP, replacing them for green products, and recycling. Here we tested the efficiency of online nudges (images and short messages) for promoting MP-conscious behavior in Spain (n = 671). The perceived level of environmental responsibility and the willingness to adopt R-behaviors were measured. Messages about seafood with MP and plastic-polluted marine environment were more efficient than images of animals killed by plastics. Feeling responsible for MP pollution predicted R-behavior intention. Women would adopt more R-behaviors than men, while men were more sensitive than females to the proposed nudges. Raising the sense of environmental responsibility would be priority in education campaigns. For different cultural sensitivities to animal suffering, evoking environmental health instead of threats to wildlife would be generally recommended.

7.2. Introduction

7.2.1. The microplastics crisis and proposed solutions

Plastic waste is increasing and already exceeds the capacity of plastic pollution mitigation (Borrelle et al., 2020). We are paying an enormous toll in environmental and human health (Rodrigues et al., 2019), not to mention the deterioration of marine ecosystems that are sinks for plastic waste (e.g., Grant et al., 2021). Microplastics (MP thereafter) produced from the breakage of larger plastics, or directly as microbeads in personal care products and cleansers, pollute aquatic environments, enter the food chain and release harmful toxic chemicals (Yuan et al., 2022).

Solutions to stop MP pollution are urgently needed. Scientists agree on the need to involve different stakeholders in the fight against MP: the science should find ways to recover and recycle MP from the polluted environment (Chen et al., 2022; Gao & Liu, 2022); the industry should develop alternative products to replace microbeads (Hunt et al., 2021) and plastics (e.g., Rosetto et al., 2019); the governments should implement measures towards MP bans and/or phase out (Anagnosti et al., 2021; Deme et al., 2022; Mitrano & Wohllenberg, 2020); and individual consumers should adopt sustainable consumption habits eliminating goods with plastics and MP from their shopping basket (Chang, 2015; Yoon et al., 2021). These changes are a challenge for the whole society that needs to advance towards cleaner ways of production and consumption without clear guidelines regarding this emerging contaminant.

Top-down approaches are being already taken, because an increasing number of countries have banned microbeads from some products like cosmetics (Anagnosti et al., 2021). This approach is double effective because citizens of countries with plastics and MP bans will to control MP in their daily life more than those where legislations are less restrictive (Garcia-Vazquez et al., 2023). However, many products that contain primary MP like glitter (Yurtsever, 2019) are not considered in MP bans yet. Thus, conscious behavior of individual consumers is much needed to stop the increase of MP pollution today. In this study, we will try a simple psychosocial intervention based on online exposure to images to identify the type of

messages that could be more efficient to stimulate consumer behaviors that prevent MP waste.

7.2.2. Theoretical background

The R imperatives (Resource Value Retention Options) have been proposed to advance towards sustainability through circular economy (Reike et al., 2018), Recycling being the implementation measure most measured and assessed (Johansen et al., 2022). Plastic recycling has limitations because some countries export the majority of their plastic waste to countries where it is just burnt, not properly recycled (Heller et al., 2020; Law et al., 2020). On the other hand, not all the plastics are equally recyclable (Rahimi & García, 2017). Burrows et al. (2022) found that miscommunication in the labeling of plastic items is one of the causes of limited effectiveness of recycling, often failing to indicate if a plastic is recyclable or not, and if there are regional facilities for recycling. In the particular case of MP, in practice Recycling would be inefficient as a general approach to treat them because they are difficult to recover from general waste due to their small size (Gao & Liu, 2022; Ruggero et al., 2020). Other R behaviors are needed in this case, especially for primary MP such as microbeads. Refuse and Reduce the consumption of products with MP are effective for limiting MP waste if the consumer knows what products contain microbeads or MP. However, as it happens for plastic labels (Burrows et al., 2022), the representation of MP on product labels is insufficiently clear, since being unable to identify microbeads from labels was one of the main obstacles for the reduction of MP reported by students in Mexico and Spain (Garcia-Vazquez et al., 2023).

Even being imperfect for unclear labeling, it is evident that adopting R-behaviors is better than doing nothing to solve the current global MP crisis. The R imperatives that depend on individual consumers (like refusing or reducing plastics consumption, or sorting waste for recycling) can be promoted in different ways. The theoretical framework of pro-environmental or green consumer's behavior generally accepted follows the Theory of Reasoned Action (Ajzen & Fisbein, 1980) and its extension in the Theory of Planned Behavior (Ajzen, 1991), where positive attitudes (assessments of self-performance) towards a pro-environmental behavior, together with perceived control and subjective norms, determine the intention to behave pro-environmentally; such intention plus environment consciousness will finally determine the actual behavior. These theories have been supported from varied studies on green behaviors, like purchasing sustainable clothes (Rausch & Kopplin, 2021) or recycled shoes (Yadav et al., 2022), also for MP control willingness (e.g., Chang, 2015).

Understanding the consequences of the individual behavior is necessary to change it; knowing the impacts of pollution is determinant to align with Recycling, Reusing and Reselling behaviors (Khan et al., 2019). Interventions to reduce waste often recall social norms and education (Byerly et al., 2018); for example, role-playing as children working in Congo cobalt mines increases recycling of mobile phones in Spain –cobalt being essential in electronic devices (Garcia-Vazquez et al., 2021). Simpler interventions are also effective. Nudges like reminders, changing the design of an object, labels or images may suffice to help the consumer to make a quick pro-environmental decision (Wee et al., 2021). Nudging based on short messages can promote different R-behaviors, like recycling food waste (Linder et al., 2018), reducing water (Bhanot, 2018) and energy (Cappa et al., 2020) consumption,

and others. We will use short informative messages as nudges in our study. We will accompany the messages with images because there are many examples that show the power of exposure to images in different countries. To mention a few, visual learning based on infographics about plastics recycling and MP formation has been proved an efficient educational tool in USA (Reed & Chen, 2022). Imagery on brochures was sufficient to change environmental attitudes in Australian students (Soutter & Boag, 2019). Wu and Paluck (2021) showed that a simple image of golden coins on the floor was enough to change waste disposal behavior in Chinese workers. Luo et al. (2022) found that the image of a marine animal trapped in plastic debris reduced significantly plastic waste in an experiment in Canada. In this sense, animal images are widely employed to elicit emotions like affect (e.g., Whitley et al., 2020) that helps to increase pro-environmental intentions.

Evoking images related with the sea could be especially efficient. Since the majority of media news focuses on MP content in seafood due to marine MP pollution (Völker et al., 2020), the public is generally concerned about MP impacts on health due to MP ingestion (Deng et al., 2020), and also by MP environmental impacts on the sea (Catarino et al., 2021). Working with ocean imagery (the way people imagine the ocean), Engel et al. (2021) discovered that pro-environmental behavior is positively associated with the psychological impression and environmentalist views of the ocean. Consistently with the effect of ocean imagery, consumer's awareness about the ocean seems to be related with pro-environmental behavior related with the use of plastics in different cultures. In the UK, Nuojua et al. (2022) found that those feeling more connected with the ocean considered plastic packaging more harmful. In the same vein, feeling responsible for the marine environment is associated with recycling and reduced consumption of single-use plastic goods in Spain and Mexico (Garcia-Vazquez et al., 2022). The sense of social responsibility and feeling guilty about ocean pollution mediates between the MP risk perception and the intention to control MP in Korea (Jeong et al., 2021), thus recalling the ocean environment could be a plus for interventions aimed at increasing consumer's MP control.

Regarding the format of interventions, the Internet, including social media, is the main source of information about MP in different countries (e.g., Didegah et al., 2018; Cammalieri et al., 2020). Research has demonstrated that the use of Internet has a positive effect on pro-environmental behavior (Xiao et al., 2022), and also the efficiency of digital interventions (Wolstenholme et al., 2020). Online exposure to messages and images is easy, aligns with nudging methodology (Wee et al., 2021), and may simplify pro-environmental campaigns. For these reasons, we will use Internet as a vehicle for the planned interventions, focusing on Spain where microbeads are not banned yet (Anagnosti et al., 2021) thus individual consumer's behavior is especially important.

7.2.3. Objectives and departure hypotheses

The objective of this study was to determine if the online observation of images related with MP is sufficient to promote the willingness to adopt R-behaviors for the control of MP.

Expectations, summarized in Figure 7.1, were:

i) From the efficiency of nudging online interventions for the promotion of sustainable behaviors (Wee et al., 2021), we expect the online exposure to

information about MP impacts will suffice to increase the willingness to behave pro-environmentally.

ii) From the public concern raised by seafood MP pollution and environmental MP impacts (Catarino et al., 2021), and the power of imagery using animals (Luo et al., 2022), images recalling seafood contamination, ocean pollution and plastic threat to animals will increase the willingness to adopt R-behaviors about plastics and MP consumption; for their emotional content images of animals (Whitley et al., 2020) are expected to be more efficient than images of inanimate elements.

iii) For the importance of environmental awareness (Yadav et al., 2022), feeling responsible for marine MP pollution will be positively correlated with pro-environmental intentions regardless the treatment.

7.3. Material and Methods

7.3.1. Ethics considerations

The study was approved by the Committee of Research Ethics of Asturias Principality (Spain) and assigned it the reference CEImPA:2021.116. Researchers informed the participants about the objective, the use of their answers for research purposes only and their right to withdraw from the study in any moment. Participants signed an informed consent online. We followed the principles of the Declaration of Helsinki adhering to the European code of conduct for research integrity (All European Academies, 2017).

7.3.2. Work overview

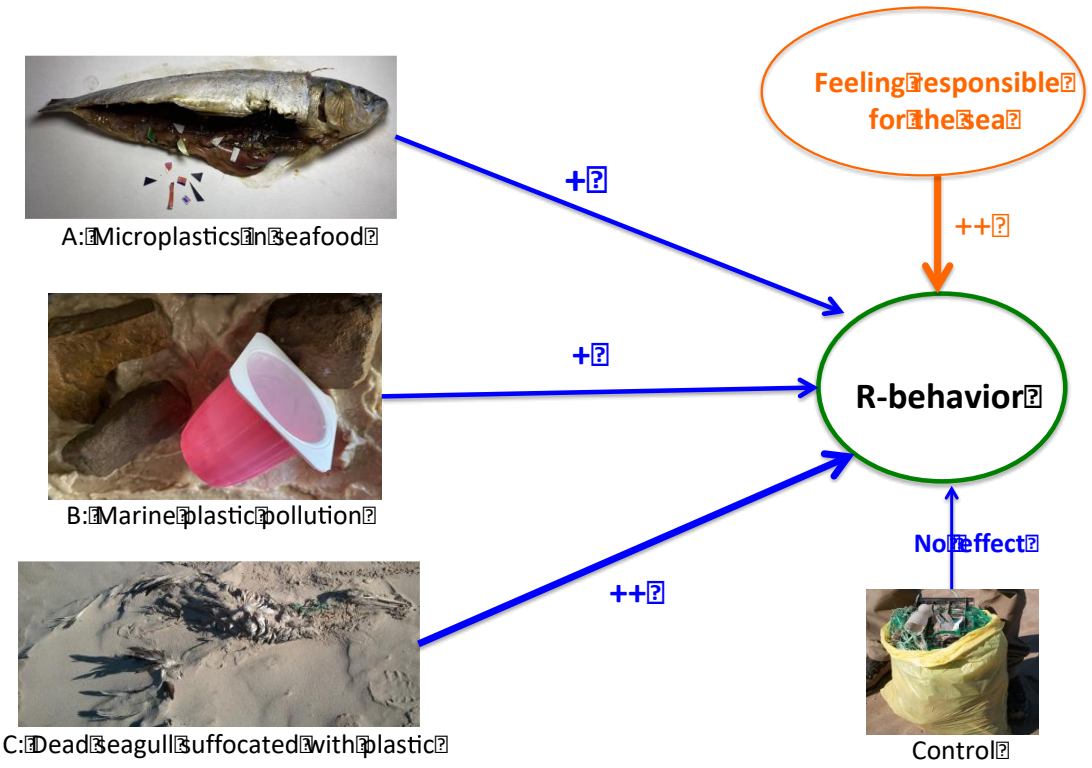
This work was organized in three different studies. In Study 6.1, R-behaviors were compared between a sample of general population (non-students) and the control group of students, both with the same introductory image of a garbage bag, to check if the condition of being a student in the experimental groups did not bias the study; with no evidences of that, the results could be generalized to the Spanish population. In Study 6.2, the results of R-behavior and pro-environmental engagement intentions were compared across four experimental groups of students: three treatments based on different images related with ocean pollution by plastics, and a control. In Study 6.3 multiple regression analysis was done on the whole sample -including students and non-students, to determine the relative weight of socio-demographic factors, the feeling of responsibility for the ocean, and the treatments, on R-behavior intentions.

7.3.3. Experimental setting and treatments

The experiment was entirely developed online. Four treatments were designed, each consisting of an image (Figure 7.1) and a short informative sentence about an issue related with MP. Treatment A evoked issues for seafood consumers. The image exhibited a fish open with MP inside, with an introductory sentence “MP may be ingested inadvertently when eating marine products like mussels of fish.” and the figure caption “Microplastics inside a fish”. In Treatment B, devoted to marine pollution, the image was a plastic object on seafloor, the introductory sentence “Microplastics represent a threat for the planet, being found even on the oceans bottom” and the figure caption “Plastic waste on the seafloor”. Treatment C intended to elicit compassion for wild animals exposed to MP waste. It combined a photo of the remains of a seagull entangled with a plastic rope with the caption “Carcass of a seagull strangled by plastics” and the introduction “Microplastics pose a risk to

emblematic species such as seabirds". Finally, in the Control treatment the image was a garbage bag full of plastic waste, with a neutral sentence not expected to elicit any attitude towards MP "This questionnaire is part of a research about microplastics, that are small pieces or fragments of plastic".

Figure 7.1. Expected effects of the experimental interventions and the feeling of responsibility for the ocean on R behavior intentions.



In the online survey, participants enter a link that takes them directly to a digital version of the questionnaire for self-administration. Subjects will find first a brief introduction stating that the information is gathered for research purposes only, and a form for the informed consent. The consent is compulsory to continue; if the case is not marked the survey ends. In the next page the introductory image and short message corresponding to each treatment are displayed, followed by a questionnaire. The first four questions (A.1-A.4) are about socio-demographic issues: gender (0 man, 1 woman, 2 non-binary), age (groups 1 to 6, by decades), educational level (1 to 6 from primary education to doctorate) and formation background according to the main formation discipline (qualitative variable: Natural sciences, Health sciences, Social sciences and Humanities, Engineering). Then a question about how often the respondent checks microbeads from personal care products and cleansers is posed (B.1; scale 1-5 from never to always), being a proxy to the actual awareness of MP. In the next section (scale 1-7), there is a question to evaluate the participant's ocean pollution awareness, formulated as "I feel personally responsible about the marine pollution caused by MP", four questions to measure the willingness to adopt R-

behaviors (Reduce plastics consumption, Refuse products with MP, Replace them for green products, sort litter for Recycling), and one question about the willingness to engage in environmental actions. The estimated time to complete this short questionnaire is about 5-10 minutes.

7.3.4. Experimental groups and procedure

The untreated group of non-students in Study 6.1 was described in Garcia-Vazquez et al. (2023). It was recruited using snowball methodology (Valerio et al., 2016), starting with university students that were asked to pass an online link to their acquaintances as explained therein (Garcia-Vazquez et al., 2023).

The four experimental groups of undergraduate students were recruited directly in the classes where the teachers provided a link to the online survey, randomly assigning each subject to an experimental group. Teachers explained that it was a research project, and the participation was for outside the class, voluntary and free, not being paid nor compensated with benefits in the course in any way. Participants were clearly informed about the project, authors, and policy for anonymous data treatment, as well as about their right to withdraw from the study at any time.

7.3.5. Statistics

7.3.5.1. Estimates of minimum sample sizes and post-hoc statistical power

Minimum sample size for adequate study power was determined for similar group sizes ($k = n_1 / n_2 = 1$), 90% minimum power, $\alpha = 0.05$, $\beta = 0.2$, anticipated means μ_1 and μ_2 and their difference Δ. The anticipated means of the control for the willingness of reduction of plastic consumption and recycling in the Spanish population were taken from Garcia-Vazquez et al. (2022), and for the willingness to refuse consumption of products with MP and replace them for green products from Spanish data in Garcia-Vazquez et al. (2023). For conservative approach we considered a 10% increase of the mean as a result of the treatment. The formula employed was:

$$n_1 = (\sigma^2_1+\sigma^2_2/K)\,(z_{1-\alpha/2} + z_{1-\beta})^2 / \Delta^2$$

Post-hoc statistical power (Φ) was calculated only for cases with significant results as recommended in Levine and Ensom (2001), based on Z-value for $\alpha = 0.05$ (1.96), mean difference Δ, group variances and sample sizes (n), according to the formula:

$$\Phi = -Z_{1-a/2} + \Delta/\sqrt{(\sigma^2_1/n_1 + \sigma^2_2/n_2)}$$

7.3.5.2. Statistical tests

Contingency analysis based on chi-square χ^2 was employed to check for homogeneity of experimental samples regarding qualitative or discontinuous variables like gender, age group or the proportion of different discipline backgrounds.

Differences between group means for socio-demographic variables like age and educational level, and for behavioral variables like checking microbeads from personal care products, were tested using ANOVA. Homoscedasticity was checked from Breusch-Pagan test and normality from Shapiro-Wilk test. Non-parametric Kruskal-Wallis test was used when normality requirement was not met. When homoscedasticity was not met Welch's F test was employed. In the experiment, two-way ANOVA was employed to determine differences in means between groups for

each factor i.e., behavioral intentions (five levels) and treatments (four levels) and the interaction between factors. Repeated-measures ANOVA was employed to compare between treatments considering simultaneously the five behavioral intentions. Post-hoc pairwise Tukey tests were conducted after significant ANOVA; *t*-test was employed to compare means between two samples, or Mann-Whitney when normality was not met.

Effect-sizes for the comparisons between two means were measured from Cohen's *d* and the effect size correlation r_{YI}. The statistics ω^2 was used as an estimator of effect size in ANOVA analysis. Cramer's V was employed as a proxy for the effect size in contingency analysis, as in Razzini et al. (2020).

Multiple regression analysis was employed to determine which independent variables, i.e., gender, age, treatment and attributed personal responsibility, predicted the variation of the dependent variables, i.e., the mean behavioral intention. To transform the treatment into a quantitative variable we order the treatments by effect, giving 0 to the control and up to 3 to the rest, ordered by the relative effect. Statistics was performed with free software PAST version 4.12 (Hammer et al., 2001).

7.4. Results

7.4.1. Overview of experimental groups

With the setting and values explained in 7.3.4.2, the minimum sample size required for 80% statistical power was 47, 58, 65, and 45 for the willingness to reduce plastic consumption, recycle, refuse products with MP and replace them with green products, respectively.

In total 324 people participated in this study: 73, 86, 82 and 83 for treatments A, B, C and the control respectively. All the group sizes were larger than the minimum sample sizes estimated, thus the study can be considered robust.

The four experimental groups were quite homogeneous; a description is presented in Table 7.1. The majority of participants were females between 18 and 30 years old, with mean educational level higher than secondary education, and had a background in social sciences. No significant differences between the four experimental groups were found for any of the considered socio-demographic factors: gender (contingency $\chi^2 = 6.36$, 3 d.f., $p = 0.095 > 0.05$ n.s., moderate Cramer's V = 0.14), age (Kruskal-Wallis tie-corrected Hc = 2.673, $p = 0.447$ n.s.), mean educational level (Kruskal-Wallis Hc = 2.457, $p = 0.483$ n.s.), and the profiles of formation disciplines (contingency $\chi^2 = 10.2$, 9 d.f., $p = 0.33$ n.s., small Cramer's V = 0.103). Thus, we can reasonably assume that the groups are similar enough to control biases from these factors in the experiment.

Table 7.1. Description of the experimental groups.

	A	B	C	Control
n	73	86	82	83
% females	65.7%	74.4%	58.02%	69.9%
Mean age group	1.18 (0.75)	1.1 (0.47)	1.16 (0.64)	1.25 (0.44)
Mean educational level	2.41 (0.86)	2.42 (0.64)	2.54 (0.76)	2.46 (0.72)
% Natural sciences	11.1%	17.4%	19.7%	18.7%
% Health sciences	13.9%	16.3%	21%	11.3%
% Social sciences & Humanities	72.2%	61.6%	53.1%	63.7%
% Engineering	2.8%	4.7%	6.2%	6.3%
Checking microbeads from products	1.37 (0.74)	1.42 (0.87)	1.45 (0.89)	1.56 (0.92)
Personal responsibility attribution	4.33 (1.78)	4.24 (1.67)	4.48 (1.79)	3.92 (1.97)

Note. **The following socio-demographic characteristics are given: self-informed gender as proportion of females; average age group, as 1 = 18-30, 2 = 31-40, 3 = 41-50, 4 = 51-60, 5 = >60; mean formation level being 2 secondary, 3 graduate, 4 post-graduate and 5 doctorate; and formation disciplines as percentage of participants of each discipline. The mean frequency of checking microbeads from cleansers and personal care products is presented (from 1 = never to 5 = always), as well as the feeling of personal responsibility for MP pollution (from 1 = totally disagree to 7 = totally agree). Sample size = *n*. Standard deviation in parentheses.**

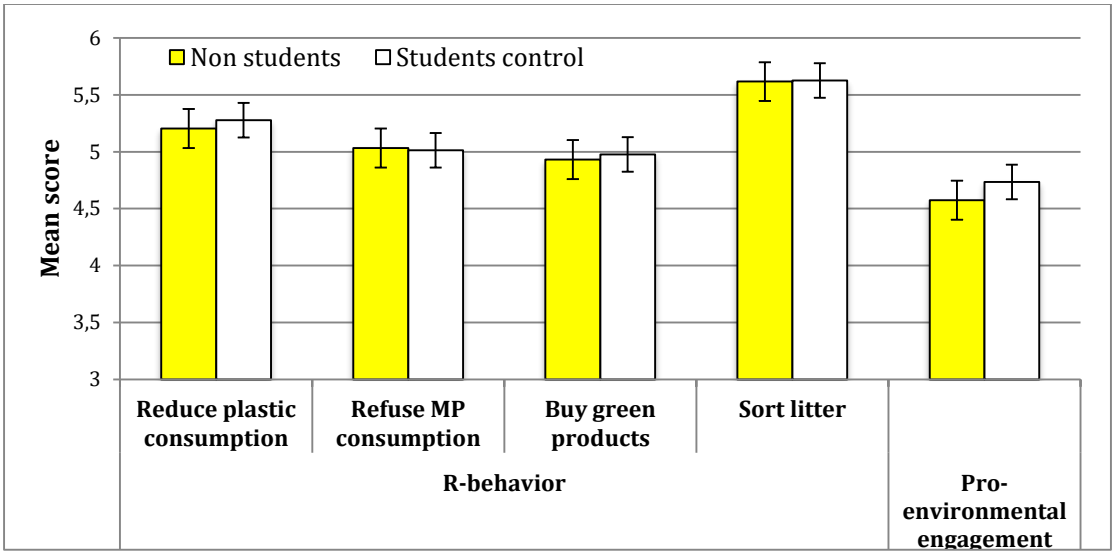
The raw data of the four experimental groups are provided in the Supplementary Table 7.1.

7.4.2. Study 6.1

As described in Garcia-Vazquez et al. (2023), the non-students sample size was $n = 347$, being 149 women (42.9%), 196 men (56.5%) and two non-binaries. The mean age group was 2.62 ($SD = 1.4$) and the average educational level 3.3 ($SD = 0.8$), meaning that the majority were graduate or above. Compared to the groups of students (Table 7.1), this sample of Spanish non-students had a higher proportion of men, education level, and, logically, a higher mean age (statistics not shown). The mean feeling of personal responsibility for MP pollution was 3.93 ($SD = 2.07$); it was 3.92 ($SD = 1.97$) for the control group of students, indeed not significantly different and with almost negligible effect size ($d = 0.005$, $r = 0.002$). The mean frequency of microbead checking was 1.65 ($SD = 1.08$), not significantly different of that of control students presented in Table 1 (mean = 1.56, $SD = 0.92$; $t = 0.686$ with $p = 0.49$, very small effect size with $d = 0.089$, $r = 0.045$).

The mean values for the five behavioral intentions in the group of non-students were very similar to those found for the control in the experiment, almost identical (Figure 7.2). Accordingly, the individual mean of these behaviors was not significantly different between the two groups of subjects (5.2 with variance 3.1 in the group of non-students versus 5.22, variance 2.84 in the control group of students; $t = 0.126$ with $p = 0.89$). The effect size was very small with $d = 0.026$ and $r = 0.013$.

Figure 7.2. Pro-environmental behavior intentions in the group of non-students (*n* = 347) compared with the control group of students (*n* = 83). Results are presented as mean scores of each behavioral intention, for each group (standard errors as capped bars).



In these groups the willingness to adopt sustainable behaviors was not the same for the five proposed actions (ANOVA $F = 16.12$ with $p < 0.001$, $\omega^2 = 0.027$). Recycling was the preferred R-behavior, and pro-environmental engagement the least desired action, only not significantly different of Replacing (buying green products) that was the second least preferred (Figure 7.2, Supplementary Table 7.2).

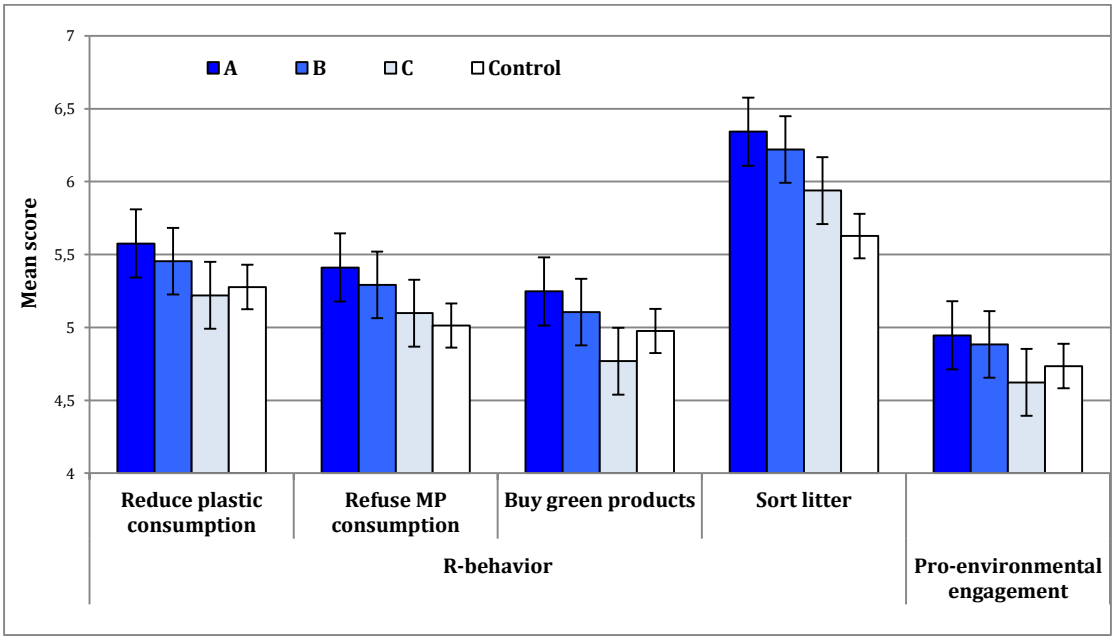
The similarity of student and non-student samples would suggest that the results obtained in this study are at least moderately representative of the general population and not limited to Spanish students.

7.4.3. Study 6.2

The frequency of the four experimental groups for the behavior of checking microbeads from cleansers and personal care products was very similar (Table 7.1), and not significantly different among groups (Kruskal-Wallis Hc = 2.899, $p = 0.408$ n.s.). Thus, the results of the experiment would not be biased by differences between groups regarding the awareness about MP.

Pro-environmental behavior intention was different among the four experimental groups (Figure 7.3). For the five behaviors considered, those exposed to a picture of a MP-polluted fish (group A) declared the highest willingness to reduce plastic and MP consumption (Reduce), buy eco-friendly products (Replace), sort litter (Recycle) and collaborate in pro-environmental actions. The next group was the one exposed to a picture of plastics on the marine bottom (group B). Group C, exposed to the photo of a dead seagull suffocated with plastics, was the next in the reduction of plastic consumption and recycling, but the last in the other three proposed behaviors (Figure 7.3). The mean of the five intended behaviors followed the order A > B > C > Control (5.5 ± 0.79, 5.39 ± 0.82, 5.129 ± 0.83, and 5.125 ± 0.91, respectively).

Figure 7.3. Results of the experiment presented as means of the pro-environmental behavior intentions considered. Experimental groups were exposed to images: A, contaminated seafood; B, plastics in sea bottom; C, dead seagull suffocated with plastic ropes; Control, a bag with litter. Standard errors as capped bars.



From two-way ANOVA results, the willingness to adopt behaviors aimed at MP control was significantly different amongst both the treatments (F = 5.01, p = 0.002) and the types of behavior (F = 24.87, p < 0.001) in this experiment (Supplementary Table 7.3).

Regarding the type of behavior, as in the Study 6.1 *Recycle* was clearly the preferred option, significantly above the rest (Supplementary Table 6.4 for post-hoc pairwise test), followed by *Reduce* plastic and *Refuse* MP consumption (both significantly higher than pro-environmental actions). Then *Replace* was not significantly different of *Reduce* and *Refuse*, neither of pro-environmental engagement that was the least preferred behavior (Figure 7.3, Supplementary Table 7.4).

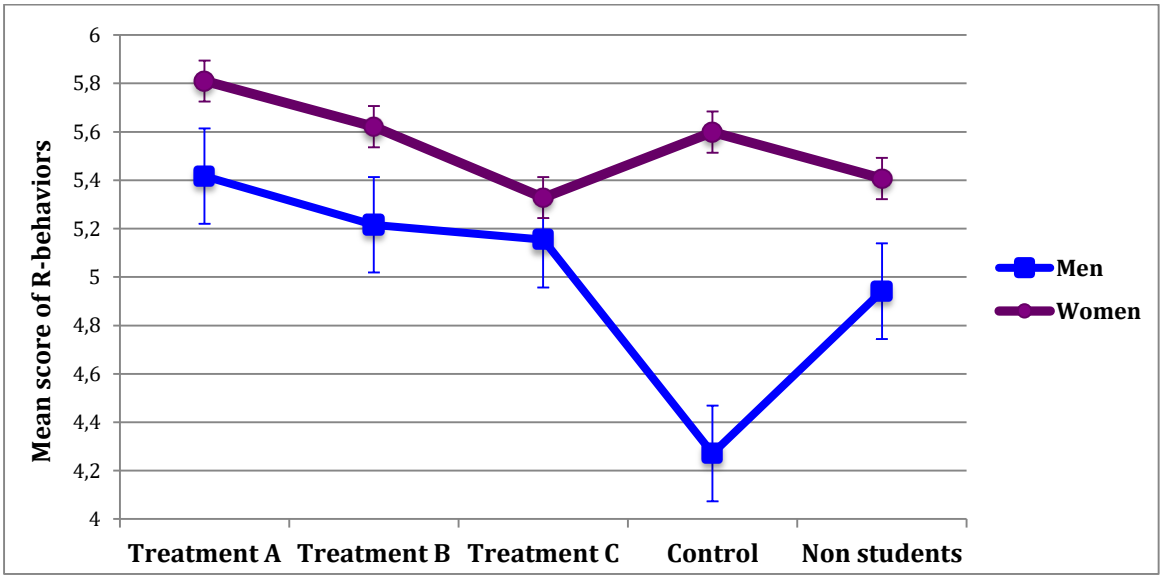
The treatment was also significant in two-way ANOVA. The objective being to test the effect of treatments on all the behaviors, we conducted an ANOVA test of multiple measures (five measures of intended behavior to control MP pollution). The result was highly significant with F = 17.2 and p < 0.001. Post-hoc tests demonstrated that both A and B treatments increased pro-environmental behavior intention in comparison with the control (large effect sizes of d = 1.346 and r = 0.558, and d = 0.943 and r = 0.426 respectively; respective statistical power of Φ = 84.3% and 57%), while treatment C did not differ from the control (Supplementary Table 6.5) with small effect size of d = 0.014 and r = 0.07. A and B treatments also differed significantly from C (see Supplementary Table 7.5). Thus, the relative efficacy of the treatments observed in Figure 7.3 was confirmed from this statistical analysis.

7.4.4. Study 6.3

In this study we run multiple regression with the mean of R-behaviors as dependent and interventions (treatments), the awareness of MP proxy (the frequency of checking microbeads from product labels) and socio-demographic variables, considering together all the subjects of these studies. Controlling the rest of variables, treatment efficiency indeed predicted R-behavior intention (t = 2.784, p = 0.006, r^2 = 0.01; Supplementary Table 7.6), consistently with ANOVA results in Study 2 (see Supplementary Table 7.3). The self-attributed responsibility for MP pollution highly significantly predicted the willingness of R-behavior (t = 12.78, p < 0.001, r^2 = 0.201). The actual awareness of MP, here represented from the behavior of checking microbeads from product labels, did not predict significantly R-behavior intentions (t = 0.11, p = 0.912 n.s.). Of the socio-demographic variables considered only the gender was significant: being a woman (because the sign was positive, and coding was woman = 1, man = 0) predicted significantly the willingness of adopting R-behaviors in the samples here studied (t = 3.112, p = 0.002, r^2 = 0.022; Supplementary Table 7.6).

The effect of the gender in the whole samples was unexpected, because in the sample of non-students alone, the effect of the gender was not significant ($F_{3, 565}$ = 1.67, p = 0.17, > 0.05, n.s.; Garcia-Vazquez et al., 2023). To understand better this effect, we conducted one-way ANOVA analysis to check the effect of the experimental treatments in men and women separately. Results showed that women declared higher R-behavior intention means than men, in all the experimental groups and in the non-students (Figure 7.4), which explains the significance obtained for the effect of gender in multiple regression analysis in this study. However, in women the differences between the five groups were not significant (Welch's F_{140} = 1.242, p = 0.296, ω^2 = 0.004). Only Treatment A had a higher R-behavior than the Control and the non-students, but the values were not much different. Only the largest pairwise difference (between Treatment A and the lowest Treatment C) was marginally significant (< 0.10 but > 0.05): t = 1.91, p = 0.059, Cohen's d = 0.41.

Figure 7.4. Means of the pro-environmental behavior intentions found in the experimental groups (Treatments A, B, C and Control) and in the group of non-students, by gender. Standard errors as capped bars.



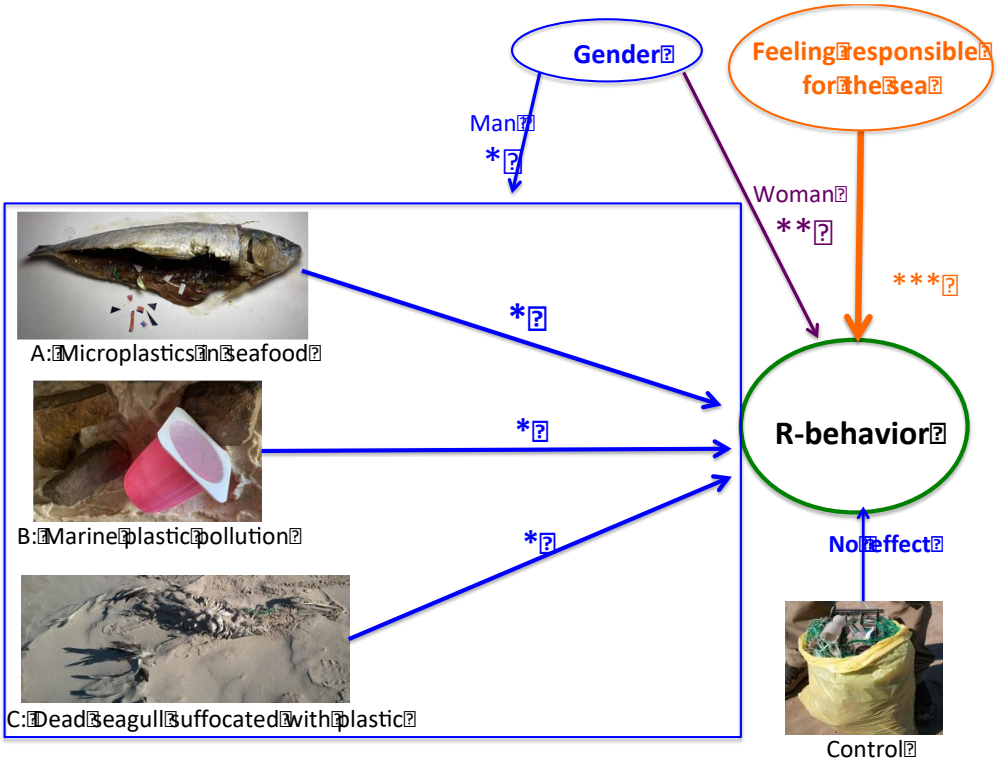
In the case of men, the results were clearly different from those of women. First, in male students all the treatments had higher means than the control (Figure 7.4), and the difference between student groups was significant ($F_{3,100} = 2.99$, $p = 0.03$, $\omega^2 = 0.054$). Even the least efficient treatment C had a significantly higher mean of R-behavior intentions than the control ($t = 2.17$, $p = 0.03$, moderate $d = 0.203$); indeed, the mean of Treatment A was also significantly higher than that of the control ($t = 2.38$, $p = 0.02$, Cohen's $d = 0.702$), as it was that of Treatment B ($t = 2.05$, $p = 0.046$, Cohen's $d = 0.619$). The apparent difference between the experimental control and the group of non-students was not significant: respective means of 4.27 with $SD = 1.85$ and 4.94 with $SD = 1.78$; $t = 1.7$, $p = 0.09$, $\omega^2 = 0.26$. Summarizing these results, the treatments had a significant effect in student men but not in women in this study.

7.5. Discussion

7.5.1. Accomplishment of departure expectations and study novelties

Here, we demonstrate the efficiency of the online exposure to images and short informative messages as nudges for increasing the willingness to control MP, confirming the departure hypotheses under some conditions that are summarized in Figure 7.5. Briefly, the nudges employed in this online experiment promoted a significant increase of the willingness to adopt R-behaviors (Hypothesis i) in men. Images of dead marine animals entangled with plastics increased R-behavior intentions, but not more than images of seafood polluted with MP or plastic garbage on the sea bottom (Hypothesis ii). In line with Jeong et al. (2021), feeling responsible for marine MP pollution was a highly significant predictor of the willingness to adopt R-behavior confirming Hypothesis iii. Finally, being a woman (versus a man) predicted higher R-behavior intention, but the exposure to the nudges employed in this experiment was not significant in student women.

Figure 7.5. Visual summary of the results of this study.



Note. **The importance of feeling responsible for the sea and the effect of gender – interventions being significantly effective only in men- are represented by arrows. R-behavior is the mean willingness to adopt the five pro-environmental behaviors considered: Recycle, Reduce, Refuse, Replace products with plastic or microplastics, and engage in pro-environmental activities. Significant increase of R-behavior intention is marked as * for $p < 0.05$ or *** for $p < 0.001$.**

These results are novel in various aspects. First, the efficiency of nudging to increase pro-environmental behavior is already known (Wee et al., 2021, and references therein), but to our knowledge this is the first experiment that demonstrates R-behaviors can be promoted from online nudging based on MP. Second, in our experiment we found a significant effect of the gender, women willing to adopt R-behaviors for the control of MP more than men but not responding to the exposure to the nudges as men did. This indicates a complex effect of the gender in these behaviors related with MP control, as it happens with other pro-environmental behaviors with results sometimes contradictory or inconclusive (Xiao & McCright, 2015). A higher pro-environmental attitude in women has been found in other studies. For example, the positive effect of the use of Internet on pro-environmental behavior was more pronounced in Chinese women than in men (Xiao et al., 2022), and the same happened for the willingness to reduce MP emissions (Deng et al., 2020). In Spain, the intention to reduce single-use plastics consumption is higher in women than in men (Garcia-Vazquez et al., 2022); however, no significant effect of the gender was found for the willingness to reduce MP, in the same sample of general population employed here in Study 1 (Garcia-Vazquez et al., 2023). When the general knowledge of pollution is taken into account, no significant effect of the gender on pro-environmental behavior to control plastics can be found in Portugal (Soares et al., 2021). Different specific factors may affect pro-environmental behavior in each

gender. For example, Vicente-Molina et al. (2018) found that university students do not fit the gender stereotype of women purchasing green and recycling more than men, which was interpreted as a decreasing importance of gender roles in environmental tasks due to gender equality laws and social transformation in the Basque Country. For these authors, men are more sensitive than women to programs attempting to influence their behavior towards the environment because they have more elastic pro-environmental values (Vicente-Molina et al., 2018). Our results would be consistent with their findings.

A saturation effect could be also considered here to explain the lack of effect of the nudges in women. In the present case, women seem to be already behaving pro-environmentally more than males, also in the control and in non-student samples, thus the exposure to more information about the impacts of MP would not have much effect on them. In men, with more room for improvement of pro-environmental behavior, the exposure to new information about MP impacts would induce the willingness to change their behaviors. A similar reasoning was employed by Garcia-Vazquez et al. (2023) to explain the lack of effect of the knowledge about MP, confirmed here. This effect was found in other studies where highly aware subjects do not increase significantly their pro-environmental behavior when they are exposed to new environmental information and campaigns (Kim et al., 2018; Cammalieri et al., 2020).

Another novelty of our results was the unexpected lack of effect of a dead seagull. In their experiment in Canada, Luo et al. (2022) found a higher impact of signage with marine animals entangled with plastics than of any other type of signage. However, in our results we did not find that effect when using an image of a suffocated seagull. On the contrary, that image did not increase the intention of pro-environmental behavior compared to the control. Cultural differences could explain this apparent contradiction. Spain is one of the European countries with the lowest concern about animal suffering, which is reflected on bullfighting popularity that, although declining in the last decades, is still supported from different sectors of the society (Andrade, 2022). Spaniards also exhibit a low willingness to adopt restrictive regulations on animal welfare, compared with other countries (Pejman et al., 2019). Thus, the relatively low effect of messages based on animal damage seems to be coherent with a culture where animal welfare is not a priority. An alternative or additional explanation could be the clear negativity of the image of a dead gull. Chen et al. (2016) found that fear through negativity has limiting impact on behavioral changes, and Soutter and Boag (2020) found that positive images elicit pro-environmental behavior changes better than negative images. This, together with cultural aspects, could explain this particular and unexpected result.

Finally, significant differences between R-behaviors were found in this study. Recycling was the preferred R-behavior in all the experimental groups. This may be expected in a country like Spain where the citizens adhere frequently to this behavior (Escario et al., 2020; Garcia-Vazquez et al., 2022).

7.5.2. Practical implications

Some practical recommendations could be derived from this study. First, from the efficiency of nudges using images found in our results we could recommend an improvement in labeling of products with MP using images or pictograms to help consumers to make informed choices. Burrows et al. (2022) recommend adding an understandable sustainability scale on plastic labeling, for the consumer to be

informed about environmental and human health issues related to plastic use. Today, the European Chemistry Agency (ECHA), that is the European Union chemicals regulator, is in the process of restricting the use of intentionally added microplastic particles to consumer or professional use products of any kind, after European Commission's request (https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18244cd73, accessed March 2023). Until the time of restrictions comes, signs about the potential risks of the main chemical of microbeads or MP particles should be added to the label of products containing them. Examples about how to represent those risks visually (as nudges) are the pictograms employed by the ECHA (https://echa.europa.eu/regulations/clp/clp-pictograms, accessed March 2023). From our results, consumers may be especially sensitive to those signs that recall harms for human health and/or for the aquatic environment.

The relative efficiency of pro-environmental messages depending on the culture is another of the main messages of our study. To reduce the consumption of products with MP, an emphasis should be given in Spain to the MP pollution of food rather than messages about environmental risks or animal harm, that being significant in men, would have less effect. Moreover, the image and message about seafood contamination, although only marginally significant, had the highest effect in women too. Similar explorations of most efficient messages and images to cut down MP consumption could be done in other countries to consider the characteristics of local cultures in interventions for environmental awareness.

Public campaigns of information could also take into account the effect of the personal responsibility found in this and other studies (e.g., Jeong et al., 2021; Garcia-Vazquez et al., 2022). Recalling the individual responsibility and the power of consumer's choices to stop current environmental deterioration could be added to informative posters, infographics, brochures and messages, as well as to the public speech of aware politicians and environmental agents if a change from the bottom – the consumer- is sought.

7.6. Conclusions

This study demonstrates the efficiency of nudges consisting of images and short messages for the increase of the willingness to control MP. These nudges had a significant effect only on men, perhaps because women had already a higher willingness to act pro-environmentally than men.

Although in other countries images of animals impacted from plastics pollution are highly effective in the promotion of pro-environmental behavior, in this study such an effect was not found. This could be interpreted as a possible consequence of the Spanish culture, where animal welfare is a relatively low priority.

According to a strong alignment of Spaniards with recycling behavior, Recycling was the preferred R-behavior chosen by all the participants in this study. Future interventions to increase consumers' control of MP should be tailored taking into account cultural aspects.

CHAPTER 8

GENERAL DISCUSSION

8.1. Contributions to the understanding of psychosocial drivers of microplastics

8.1.1. Contributions by study

The meta-analysis conducted in Study 1 served to identify knowledge gaps and research directions that will be discussed in the section 8.2. Its results helped to refine the research questions to be investigated in the rest of studies of this Thesis as well. One of the recommendations arising from the study, supporting earlier Pahl and Wyles (2017)'s perspective, was the need to undertake qualitative, quantitative and experimental quantitative researches for the exploration of public awareness, and to design interventions against microplastics emissions. Studies 3, 4, 5 and 6 were planned as a response to those needs.

Study 2 served to understand the key psychosocial drivers in the microplastics crisis that heen identified by 2021. Although scientific publications on this topic started before 2007, the first observation was a surprisingly scarce number of articles with real data about microplastics and psychology (only 17). Especially in comparison with the number of reviews on the topic (16), and the hundreds of articles about plastics pollution, recycling, and littering, that mentioned microplastics as a likely sub-product of plastics waste. The impression was that the whole new field was built upon a bunch of real data and an overwhelming number of interpretations, suspicions, and projections. New data connecting social psychology and microplastics emissions, already demanded five years ago (Pahl & Wyles, 2017), were still needed. For the rapid advance of the microplastics crisis (Shen et al., 2020), it was really urgent responding to that need.

Regarding the main psychological variables that determine the willingness to control microplastics emissions, according to the Theory of Reasoned Action (Ajzen & Fishbein, 1980), knowledge was essential. This was confirmed from the three experimental studies reviewed in Study 2 (Chang, 2015; Raab & Bogner, 2020; Cammellieri et al., 2020): getting informed about microplastics, even from a simple brochure like in Cammellieri et al. (2020), was enough to increase awareness and will to control this emerging contaminant. The importance of knowing about the existence of microplastics was supported from quantitative observational studies (Abate et al., 2020; Deng et al., 2020; Herweyers et al., 2020; Yan et al., 2020).

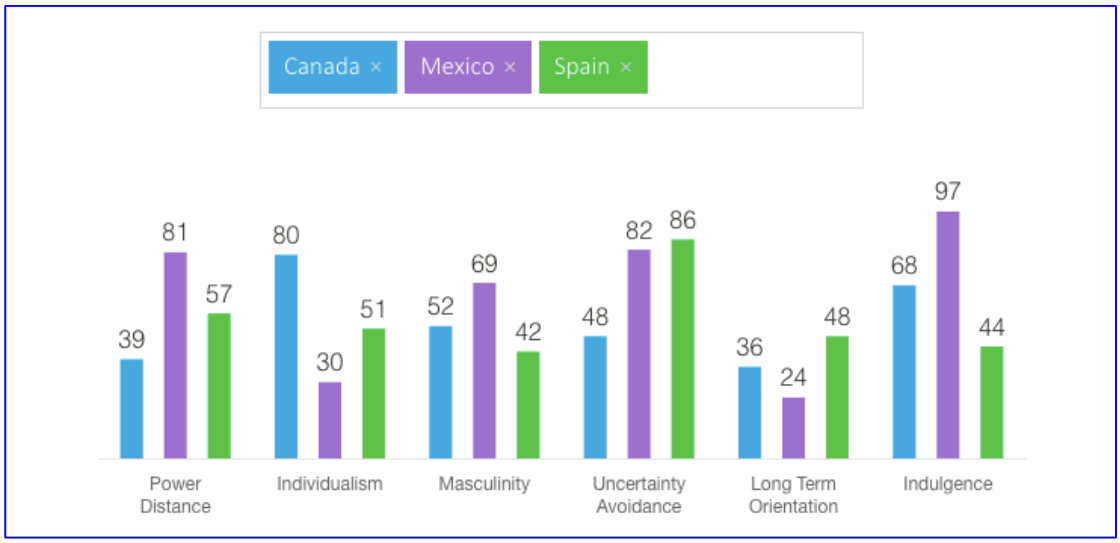
In addition to knowledge, other psychosocial features contributed significantly to the intention of controlling microplastics from Study 2. According to the Theory of Value-Belief-Norm (Chen, 2015; Stern, 2000), environmental values promoted a reduced consumption of products with microplastics (Anderson et al., 2016; Nam et al., 2017). However, the theories backing these studies were not totally supported from data in all the cases. The effect of an essential constituent of the Theory of Reasoned Action such as the perceived control (Ajzen, 2002) was not significant in Nam et al. (2017) study in the USA. The effect of the concern about microplastics perceived risks was significant in Portugal (Soares et al., 2021) and South Korea (Jeong et al., 2021), but not in China (Deng et al., 2020). These differences between studies would support cross-cultural differences suggested by Misund et al. (2020). For Hosftede et al. (2010), China is a collectivistic country scoring lower than Portugal and South Korea in uncertainty avoidance (30 versus 99 and 85, respectively); Chinese citizens would not need to be sure of the risk encompassed by microplastics to support restrictive government measures (in addition the power

distance is higher in China, 80, versus Portugal, 63, and South Korea, 80). Cultural differences will appear again when explaining other studies of this Thesis.

The map of psychosocial drivers in the microplastics crisis was completed with a new vision of the role of mass media achieved from Study 3. Biased risk frames with an emphasis on seafood contamination and human health risks (e.g., Völker et al., 2020) had been identified. However, in the countries analysed in Study 3 (Canada, Mexico, and Spain) newspapers put a strong emphasis on environmental issues (the habitat affected and the pollution), unlike in the UK (Völker et al., 2020). Interestingly, other topics were differently emphasised: headlines focused on solutions in Canada, on actors in Spain and on health in Mexico. The explanation is likely complex as the differences between countries are; the results were interpreted from the level of development (higher in Canada and Spain than in Mexico), and different cultural dimensions for each country (Hofstede et al., 2010). These are presented in Figure 8.1. The dominant Canadian culture is generally more individualistic than that of Spain, and this one is more individualistic than that of Mexico. Highly developed, individualistic countries are generally concerned about the environment (do Paço et al., 2013; Komatsu et al., 2019), and collectivistic countries are concerned about environmental threats for the impact they may cause on human health in present and future generations.

Moreover, the emotional content of the words employed by newspapers to indicate microplastics understanding was also different by country: in Canada, the majority of terms were positive of low arousal and pleasant, while in Mexico the majority were negative, of high arousal and displeasant. Spain was in the middle: positive or neutral, of high arousal and pleasant. Individualistic cultures would react more easily to positive emotions (Kitayama et al., 2000), while high, negative arousal emotions would elicit uncomfort thus feelings against a topic (microplastics in this case) in collectivistic countries (Lim, 2016); probably a reader's reaction was sought by journalists in all the countries, and they employed the words needed for that in each culture.

Figure 8.1. Differences between Canada, Mexico and Spain for cultural dimensions recognized by Hofstede et al. (2010).



Note. **Blue, purple, and green columns represent scores of Canada, Mexico, and Spain respectively. Constructed with the free tool "Compare Countries", available at https://www.hofstede-insights.com/product/compare-countries/ (accessed April 2023).**

Not surprisingly, the potential impacts of microplastics on health were emphasised by newspapers in the three countries after the COVID-19 pandemics, reflected in a significant increase of words related with health in news about microplastics in Mexican and Spanish newspapers. However, the difference pre- and post-pandemics was not statistically significant in Canada - suggesting again a culture more focused on solutions than on threats in this country. Overall, including Hofstede et al. (2010)' psychosocial dimensions closely linked to the culture was a key contribution of the Study 3. As it will be commented below, the differences in cultural dimensions may explain as well some differences between the results found in Spain and Mexico in the Study 5.

Two of the actions recommended to stakeholders by Prata et al. (2019), and many other authors, for the mitigation of microplastics pollution are reducing the use of plastics and prioritization of recycling. In the Study 4, both the behavioural intention and the behaviour of reducing single-use plastics consumption (plastic bottles and bags) and recycling were analysed. An original contribution of this study was to find a link between marine citizenship and plastics consumption. Pahl, Wyles and Thompson (2017) identified intrinsic motivations such as people's passion for or connectedness to the ocean as good fundaments for long-term engagement to reduce plastic pollution. However, the few studies reporting data on this relationship are not consistent. Users of leisure ocean resources, like surfers, highly value connection to nature and "green" thinking; but on the other hand, they value and are recognized from expensive apparels (often containing plastics), travelling to and exploring exotic destinations –thus increasing their carbon print, so leading to cultural dissonance (Langseth & Vyff, 2021). Some fishermen that live directly from marine resources are not always committed to control plastic pollution in the Mediterranean Sea (Latinopoulos et al., 2018), although in the Baltic Sea they are concerned about marine pollution and prevent fishing gear losses (Lewin et al., 2020). In Study 4, feeling responsible for the ocean predicted significantly the intention to reduce single-use plastics consumption, buy eco-friendly products and recycle. Contradicting the Theory of Planned Behavior (Ajzen, 1991), this increased intention to reduce plastics consumption and recycle promoted from environmental responsibility was not accompanied with a significant prediction of actual behaviors. Briefly, the responsibility for the sea would make people to intend reducing plastics and recycling, but not so much the real actions. Interestingly, being a woman predicted significantly the feeling of responsibility for the ocean, thus, indirectly, the behavioural intention of plastics control. This was the first effect of gender detected in this Thesis, which will be commented later.

In contrast with the psychological feeling of responsibility, the mere fact of frequenting the sea was not a predictor of pro-environmental behaviour intention regarding plastics in Study 4. This would be consistent with Latinopoulos et al. (2018) and Langseth & Vyff (2021); also with psychosocial theories like the Model of Responsible Environmental Behavior (Hines et al., 1986) where the personal responsibility is key for environmentally responsible behavior intention. However, sea frequentation was a significant predictor of actual recycling behaviour, in agreement with other studies about littering (Slavin et al., 2012; Rayon-Viña et al., 2018). The two components of marine citizenship considered would have different effects, and as a whole they seem to promote pro-environmental behaviors like recycling.

The country influenced significantly the willingness to reduce plastics consumption and recycling in Study 4, being plastics consumption much lower in

Mexico than in Spain, and recycling much higher in Spain. This was attributed to social norms –reflected in legislation- more favourable to plastics control in Mexico than in Spain, where single-use plastics bans are not in place (e.g., Borg et al., 2022); and to recycling in Spain than in Mexico, where recycling is not as frequent (Escario et al., 2020; Gibovic & Bikfalvi, 2021; Munoz-Melendez et al., 2021). This would support other studies where social norms are essential for SUP consumption behavior (Heidbreder et al., 2019; Jia et al., 2019, Jacobsen et al., 2022); indeed it confirms again the validity of the Theory of Reasoned Action and the extended Theory of Planned Behavior (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980; Ajzen, 1991), where social norms are so important to determine subjective norms. On the other hand, the effect of the country explained the lack of effect of sea frequentation on the reduction of plastic bottles consumption: Spanish students frequented more the sea but consumed more plastic bottles than Mexican students, thus potential negative relationships between the two variables was blurred at the whole sample level.

In the Study 5 a survey about the intention to reduce the consumption of products with microbeads and to buy green alternatives was conducted in Spain and Mexico. The actual behavior of checking microbeads from personal care products was also investigated. The results of this study revealed an apparent paradox with the results of the Study 2, where knowledge was central for the control of microplastics. In Study 5, the declared and actual knowledge of MP was significantly higher in Spain than in Mexico; however, Mexicans declared a higher willingness to reduce microplastics than Spaniards did and checked microbeads more often. Despite knowing less about microplastics, Mexicans declared a higher concern and willingness to control microplastics consumption. This paradox was explained because Mexico is a country already sensitized about plastics for its strict legislation with plastics bans, as seen in Study 4; thus, when hearing about microplastics in the survey (even if it was for the first time) they felt concerned and, logically, rejected them, as other studies showed because they are unnatural and unnecessary (Chang, 2015; Anderson et al., 2016).

Taking globally the subjects of Study 6, nudges based on seagulls dead by plastics suffocation were inefficient, and taking men independently the effect of this type of nudges was lower than that of images of seafood with microplastics, or sea bottom plastic pollution. In other studies images of animal suffering (entangled with plastics, for example) are more effective than other types of images (Luo et al., 2022). Without discarding the possibility of limited effect of negative messages on behavioural changes (Chen et al., 2016; Soutter & Boag, 2020), the effect of the culture may be claimed again to explain this apparently contradictory result. The dominant culture in Spain is less sensitive to animal welfare than in other countries of similar development level (Pejman et al., 2019), thus the image of a dead bird would be less threatening that the possibility of eating microplastics or plastics to pollute pristine sea bottoms. Moreover, seagulls are perceived as a problem in Mediterranean countries (e.g., Vidal et al., 1998), thus compassion for them is not very likely in Spain.

8.1.2. Cross-cultural perspective

Importantly, the Studies 3, 4 and 5 contributed to fill in one of the gaps highlighted in the Introduction and detected in the Study 2: the inequal geographical coverage of psychosocial studies regarding behaviour for microplastics control. In the review of Study 2 there was no one psychosocial study about microplastics from

Mexico, nor from Spain. The first paper reporting knowledge and attitudes about microplastics in Mexico and Spain so far (April 2023) is the Study 5 presented here, which is a significant contribution to the understanding the psychosocial drivers of microplastics. The same countries were considered in the Study 4 regarding single-use plastics consumption, and in the Study 3 together with Canada. America had comparatively fewer studies on psychosocial determinants of microplastics pollution than other regions in Study 2 (see Figure 3.1 in Chapter 3); Latin American countries are generally considered as understudied for pro-environmental behavior (e.g., Bronfman et al., 2015; Tian & Liu, 2022). This Thesis improves in some extent the coverage of this gap.

From the discussions above, a main contribution of this Thesis was to put the countries' culture upfront. Cultural differences (individualism versus collectivism) may explain the noticeable difference in the focus of media news about microplastics, and in the use of words of different emotional content in Canada and Spain (individualistic) versus Mexico (collectivistic). In addition, the collectivism in Mexico (Figure 8.1) likely contributes to explain the differences between countries. Consumers engage in behaviors that benefit the society as a whole in collectivistic cultures, regardless of the personal benefit (Moon et al., 2008; Sreen et al., 2018). This cultural dimension many be concomitant with the social norms and legislation favorable to plastics control commented in the Study 4. Indeed, it is also consistent with a pressure from the media to control microplastics since, as they are presented in Mexican but not in Spanish newspapers, microplastics endanger not only the environment but also the human health (see the Study 3).

8.1.3. Gender perspective

The gender perspective was important in this Thesis, being a noticeable contribution in this field where very few studies have tackled this important aspect. In Study 2 only two studies out of 17 (11.8%: Abate et al., 2020; Deng et al., 2020) analysed differences by gender, while in Study 1 gender was so rarely mentioned that it was not retained as a relevant word in the analysis.

In the Study 6, Spanish students exposed to different nudges manifested significantly greater willingness to control microplastics than the control sample, but this happened only in men. Being a woman predicted higher R-behavior intentions than being a man. However, in women the effect of the nudges was not globally significant as it was in men. This apparent contradiction deserves a detailed analysis. The first part, that is, women having greater pro-environmental intentions, could be expected from other studies where women will to control microplastics emissions more than men do in China (Deng et al., 2020). In Study 6, women would fit the stereotype of being more pro-environmental than men that has been confirmed in different contexts and countries (McCright, & Sundström, 2013; Galbreath, 2019; Nadeem et al., 2020; Ramstetter & Habersack, 2020), with some exceptions (e.g., Shen & Saijo, 2008; Vicente-Molina et al., 2018).

Regarding significant responses to nudges only in men, Vicente-Molina et al. (2018) found that student men exhibited more elastic pro-environmental values and suggested this was the reason for men to respond better than women to programs aimed at changing environmental behaviours. Their lack of response to the nudges could be interpreted as Vicente-Molina et al. (2018) did, perhaps from more elasticity in men that makes them to be more sensitive (to nudges based on microplastics, in this case). Another explanation could be that in women of Study 6, who were already

sensitized about environmental problems, the exposure to new arguments did not make a difference. This happened with environmentally aware subjects in other studies and could be applied to this case as well (Kim et al., 2018; Cammalieri et al., 2020). In that specific study where the majority were university students, the sample was very homogenous and men and women were comparable in all other respects. However, since some snowball sampling was made in all the studies of this Thesis, the intervention of other explanatory variables could not be totally ruled out. In any case the effect of the gender seems to be complex and would need a deeper exploration in further studies.

As a final remark, despite the widespread stereotype of women as caregivers and nurturers closely connected to Nature ("Mother Nature;" Liu et al., 2019), the International Union for the Conservation of Nature reveals that gender equality is still very far in environmental decision making. Women hold only 15% of top jobs in environmental sectors (https://www.iucn.org/news/gender/202103/new-data-reveals-slow-progress-achieving-gender-equality-environmental-decision-making; accessed April 2023), including fisheries (Siles et al., 2019). Perhaps taking into account gender aspects in all the fields of environmental psychology could help to advance towards gender equality.

8.2. Identification of research needs

The first meta-analysis (Study 1) served to identify urgent psychosocial research needs in the field of the microplastics crisis. The majority of reviews focused on the individuals and their habits (e.g., Abalansa et al., 2020; Lam et al., 2018), while more perspectives papers highlighted the governance (e.g., Penca, 2018; Stoett & Omrow, 2021). To solve the microplastics crisis it is required a deeper, structural change towards a less plastic-dependent society (Nielsen et al., 2020). Being true that the change has started with some legislations to ban microbeads (Anagnosti et al., 2021), these are far from complete because many products containing microplastics, like glitter, are forgotten. A research need is to investigate **how the governance of plastics can be improved**, taking into account stakeholders' perspective, perceptions of microplastics, and pressures they may find to restrict the production and use of plastics.

From Study 1, the balance between companies and individuals is far from achieved; the majority of studies are focusing on individual behaviour, while in prospective studies it seems that the industry – that produces plastics and microplastics- should be in the center of research interests. A big research gap is therefore **social psychology studies on organizations and lobbies**. Most of the studies investigate corporate social responsibility placing the focus on individual companies (Landon-Lane, 2018); however, the change of the whole productive system to circular economy will need the implication of all the actors, including the plastic producers lobbies. To date there are no critical studies on the perspectives of plastics producers about changes in plastics production; on the contrary, in their publications they emphasize the sustainability of this material and the efforts they make to mitigate plastics pollution (PlasticsEurope, 2020).

A recurrent term in the psychosocial studies analyzed in Studies 1 and 2 is uncertainty; the whole microplastics crisis seems to be created from physical particles but the changes needed and how to achieve them are still debated. In agreement with Pahl and Wyles (2017), Study 1 proposed **more qualitative, quantitative and**

experimental quantitative researches to explore public awareness and to design interventions for microplastics control.

Another research need identified in Study 1 was **to understand and clarify the role of media on the transfer of knowledge from scientific grounds to the citizen**s. Supporting Schnurr et al. (2018) and Soares et al. (2020) views, because microplastics are invisible and their risk is not evident, the majority of the society needs the mass media to be informed about the microplastics crisis; indeed, incomplete or biased information may mislead to overreactions or inaction –depending on the bias- from policy-makers.

Study 2 emphasized the need **to expand the geographical and cultural coverage of psychosocial studies**, not only about microplastics but in general about different aspects of plastics consumption and littering. The African continent is still underexplored, and very few studies –including this Thesis- report data from Central and South America. Increasing the number of psychosocial studies about microplastics perception and awareness in those undercovered regions is especially important taking into account that the crisis is global, and there are no borders for microplastics pollution.

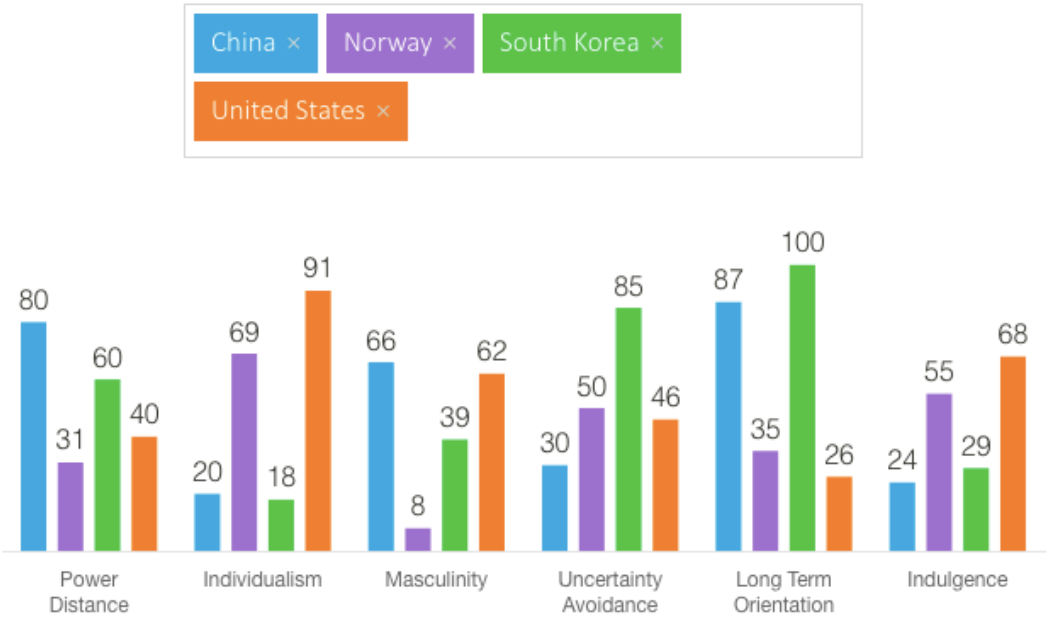
The possible lack of objectivity and biases of mass media were studied in more depth in the Study 3, which allowed to identify new research needs like a deeper exploration of the topics preferred by the newspapers. There was a discrepancy between the results of Study 3, where headlines and article bodies were more focused on the environment than on health and food threats of microplastics, and previous results where the trend was the opposite (Volker et al., 2020). This was explained in Study 3 from the timing of the two studies: the interest on environmental issues is increasing over the very last years, due to the climate crisis and the COVID-19 pandemics that put environmental alterations upfront (Damsbo-Svendsen, 2022; Mocatta & Hawley, 2020). **Recent trends of mass media environmental foci should be explored** to understand how citizens are exposed to different views of environmental issues. This knowledge could be employed to identify discrepancies between scientific facts and the vision transmitted by media, and to improve science communication accordingly.

A new question opened in Study 4 was the **difference between the effect of the two components of marine citizenship** analysed. While the psychosocial component of feeling responsible for the sea predicted behavioural intentions –but not actual behaviors, the physical component of sea frequentation predicted actual behaviors –but not intentions. The disconnection between these components deserves further exploration in the specific field of microplastics. Likely the attitudes about microplastics are not conditioned by the same factors that determine recycling and reducing plastic bottle consumption in Study 4; for example, microplastics can be eaten and breathen while marine plastic litter cannot –at least before degrading into smaller fragments. Perhaps sea frequentation is enough to increase the intention to reduce microbeads consumption and the corresponding real behaviour. If this was true, interventions recalling marine citizenship could be designed in the context of the microplastics crisis.

Study 5 confirmed the difference between country cultures regarding pro-environmental behaviour intentions and opened interesting research questions about the possible effect of cultural dimensions. As Abate et al. (2020) in Norway and Yoon et al. (2021) in South Korea, in Study 5 the concern predicted significantly the

intention to support microplastics control measures in both Mexico and Spain. This finding contradicted Chang (2015) in the USA, or Deng et al. (2020) in China, where knowledge was enough to increase pro-environmental intentions. It is curious that, for Hofstede et al. (2010) cultural dimensions, China and the USA coincide in relatively lower uncertainty avoidance in comparison with Norway and South Korea (Figure 8.2); perhaps knowing that there are microplastics out there is sufficient for wanting to control them. Indeed, interpreting the results of those authors from this single observation is merely speculative, but the effect of uncertainty avoidance would remain as a possible question mark. Moreover, in Mexico where the knowledge of microplastics was lower, the behavior of checking microbeads was more frequent than in Spain. This could be attributed to a more restrictive legislation, pro-environmental social norms, to a higher collectivism, or perhaps to any other cultural dimension. **More cross-cultural studies are needed to understand the influence of different cultural dimensions in pro-environmental attitudes**, in order to tailor interventions adequately in the different countries.

Figure 8.2. Differences between China, Norway, South Korea, and the United States for cultural dimensions recognized by Hofstede et al. (2010).



Note. **Blue, purple, green, and orange columns represent the respective scores. Constructed with the free tool "Compare Countries", available at https://www.hofstede-insights.com/product/compare-countries/ (accessed April 2023).**

Two main research questions arose from Study 6: one referred to the effect of gender, and another to the limited effect of images suggesting animal suffering. The effect of nudges occurred mainly in men, not so much in women. This could be explained from a higher psychological elasticity in environmental values in Spanish men (Vicente-Molina et al., 2018), but also from already high pro-environmental intentions in women that would not change too much with further interventions (Cammalieri et al., 2020; Kim et al., 2018). **Differences by gender in the response to pro-environmental interventions have to be explored** to understand the underlying psychosocial factors, and to design more efficient, fully inclusive interventions.

Regarding the limited effect of images of plastics-entangled animals, as seen above it could be explained from a limited sensitivity of the Spanish society to animal welfare (e.g., Andrade, 2022), or from the vision of seagulls as nuisance species in the Mediterranean (e.g., Vidal et al., 1998). Other explanation could the limited effect of explicitly negative images reported by some authors (e.g., Soutter & Boag, 2020). **The relative efficiency of different animal images as nudges should be explored**, to understand how to make a good use of animal images - perhaps emphasizing positive messages.

Finally, the pro-environmental behaviour is a **pro-social behaviour**. Following state of the art literature in this novel field, the control of microplastics has been treated here from cognitive models like the Theory of the Planned and Reasoned Action. However, other pro-environmental behaviours such as recycling have been investigated taking into account emotions (e.g., Carrus et al., 2008; Zhang et al., 2021), personality traits (Poškus & Žukauskienė, 2017; Swami et al., 2011), empathy (Berenguer, 2007; Yan & Cortese, 2023), or variables like the connection to Nature also called natural bonding (Nketiah et al., 2022; Whitburn et al., 2020). These psychosocial variables related with pro-environmental behaviour have not been tackled in depth in the field of microplastics control yet; especially emotions. Perhaps because the adverse consequences of this emerging pollution are still under research, or because the pollutant is invisible thus it requires a cognitive effort to be understood. In any case, emotions have been evoked in other cases of invisible environmental threats such as climate change, showing for example dramatic images of climate refugees (e.g., Howell, 2014) – not without a controversy (Bettini, 2013). Future research could adopt alternative points of views to explore **emotions**, **personality traits**, **connection to nature** or **empathy** as psychosocial drivers of pro-microplastics control behaviours.

8.3. Practical implications and suggested interventions

Grünzner and Pahl (2023) recognize that behavior change is one part of the solution to reduce plastics in our natural environment, but it is not sufficient because harmonized actions from different stakeholders are needed. To solve the microplastics crisis the different actors identified in this Thesis should adopt changes in their current behaviors, as citizens; owners, CEO or members of corporations; managers; politicians; and activists. Every member of our societies is involved in one or another way in this global crisis.

Starting with the stakeholders most studied to date, **consumers**, they should refuse the purchase of products with primary microplastics. Against secondary microplastics, consumers should adopt R imperatives as recycling and reusing plastics objects and accepting alternative materials. For this, interventions may be of diverse nature. Studies 4, 5 and 6 in this Thesis suggested some hints for the design of interventions.

A recommendation that comes from the three studies, is the use of the **sense of environmental responsibility** in interventions to promote behavior changes for the control of microplastics. However, blaming individuals for pollution may be not only inefficient but unfair. As Karlsson (2012) stated, "*Instead of further individual guilt, there is an urgent need to define new collective progressive projects aimed at universal affluence and natural restoration*". A normal reaction in many cases is to refuse such a guilt arguing that other actors, like corporations or the industry, are

massive polluters in comparison with a single consumer; moreover, in the particular case of microplastics responsibilities are often shifted elsewhere by different interest groups (Kramm & Völker, 2018). Reminding the general public that each one is individually responsible just for a small part of the environment around us, and that simple easy actions can make a real difference, could be a way of making the persons not guilty but simply aware of environmental issues. For example, recalling the power of consumer's choices to stop current environmental deterioration could be added to the public speech of politicians, environmental agents and journalists. To involve the whole society, probably highlighting **how useful both individual and collective actions can be to control plastics pollution** is a sound strategy to promote the endorsement of plastics and microplastics control.

The efficiency of top-down approaches in environmental issues, suggested from the Study 4, has been proved in different circumstances. **Microbeads bans** are a method to stop the production of primary microplastics successfully employed in several countries (Anagnosti et al., 2021), thus this type of legislation could be encouraged in the rest of countries where it is not implemented yet. However, the efficacy of single-use plastics bans and levies –necessary to stop secondary microplastics- has been challenged in many countries where plastic bottles and bags are still considered convenience objects (Muposhi et al., 2022). In these cases, community-driven approaches have been proposed instead. For this, **education and campaigns of awareness raising** will be also essential

Education was highlighted by the participants in Study 5, both in Mexico and Spain, as a solution to the microplastics crisis. More publicity of country's directives and the integration of the topic in formal education curricula, also suggested by Charitou et al. (2021), are proposed as likely effective actions to increase the public knowledge about microplastics and advance towards sustainable solutions.

In Study 2 it was clear that **improving scientific communication** is needed to increase the knowledge about microplastics. There is a lack of clear communication of what is known for sure and what is subjected to open interpretations. Thus any **intervention aimed at a better collaboration between scientists, environmental stakeholders and journalists** will be welcome. A possible approach is **to create and impulse networks** of scientists, journalists, environmentalists, policy-makers, and the industry, that as seen above has many interests in the use of plastics.

Simple actions like a **clear labeling of products**, indicating visually and visibly if they contain microplastics or are microplastics-free, could be sufficient to help consumers to make informed choices in those countries where microbeads bans are not in force yet. This recommendation is not of psychosocial nature, but its implementation by the industry may be complex because it involves extensive new labeling. For this, companies and the whole industry should be fully aware of both the microplastics threat, and indeed of consumers' rights. **Working together with scientists and policy-makers could help the industry** in this effort, which emphasizes again the convenience of networking around the microplastics crisis.

To help companies engaging in sustainable practices, like not exporting plastic waste to third countries, using less plastic packaging, or recycling, psychosocial tools could be employed. As commented above, encouraging the sense of environmental responsibility could help in this through, for example, the Departments of Human Resources. Psychosocial tools like **pro-environmental nudges recalling sustainable practices**, whose efficiency has been confirmed in Study 6 and in other investigations

(Wee et al., 2021), may be employed for this purpose. From the results of Study 6, nudges with images of plastic pollution have been identified here as an efficient method, especially for men. To convince both men and women, perhaps other types of images showing the results of fighting microplastics (clean versus polluted seafood, for example) would be more efficient.

Psychosocial interventions are also needed **to encourage green innovation changes in the plastics industry lobbies.** A top-down approach as suggested above may be taken, where policy-makers make it mandatory to invest in technological innovations to abandon plastics and primary microplastics. However, the current bans on single-use plastics and microplastics are being contested from the plastics industry lobbying, and as seen in the Introduction, some legislation advances were postponed or cancelled following COVID-19 pandemics. Since laws can be changed in some circumstances, or revoked under governments of different political sign, a top-down approach is not always the best to solve the microplastics crisis. The **plastics industry must be convinced of the urgent need to change the economy's dependence on plastics**. In this case, for the huge interests involved it is unlikely that nudges are sufficient. Instead, the networks working on the microplastics crisis could appeal to the sense of responsibility, having the common good as a mission; alternatively, more practical approaches could be to emphasize the long-term sustainability of the companies themselves, and the advantages of green images.

Not only the different stakeholders would need different interventions to solve the microplastics crisis. Overarching those differences by actors' interests, the cultural background (Ojinnaka & Aw, 2020) and differences in cultural dimensions between societies and countries (Hofstede et al., 2010) would require **tailoring interventions by country**. For example, the efficiency of a particular intervention based on microplastics threats will be expectedly different in collectivistic and individualistic societies, that will be more or less sensitive, respectively, to the wellbeing of future generations. This has been pointed out in the Study 3, and was consistently confirmed in the Study 5, where collectivistic Mexicans would embrace more sustainable practices even knowing less about microplastics than the individualistic Spaniards.

CONCLUSIONS / CONCLUSIONES

Conclusions

i) Mismatches between perspective articles and reviews in Study 1 revealed that, while the majority of psychosocial studies about the microplastics crisis focus on individual consumers, the main solutions identified from perspective articles refer to deeper changes in governance, production and societal organization, focusing on circular economy instead.

ii) From 17 articles published by 2021 meta-analyzed in Study 2, the main psychosocial driver investigated to tackle the microplastics crisis is knowledge. The main psychosocial framework employed in these studies was the Theory of Reasoned Action, together with Value-Belief-Norm. Important geographical gaps in this field are African and Latin American countries.

iii) The analysis of most read newspapers from Canada, Mexico and Spain in Study 3 showed significant differences between countries for the words employed in news about microplastics, more focused on solutions, threats, and actors, respectively. According to different cultural dimensions, the emotional content of relevant terms about microplastics was more positive in Canada, neutral in Spain and negative in Mexico.

iv) In Study 4, the psychosocial dimension of marine citizenship, i.e., feeling responsible for the ocean, was significantly associated with the willingness to reduce single-use plastics consumption and to recycle plastics in Mexico and Spain; in contrast, sea frequentation had a significant effect on actual recycling behavior, suggesting a disconnection between marine citizenship components. According to their respective social norms, Mexicans would adopt sustainable behaviours more frequently than Spaniards.

v) Despite knowing less about microplastics, Mexican participants in Study 5 exhibited more sustainable behaviors and behavioral intentions regarding microplastics consumption than Spanish ones, according to a stricter legislation about plastics in Mexico and suggesting the efficiency of top-down approaches.

vi) Online exposure to nudges in Study 6 revealed a significant effect of images of microplastics-polluted fish and plastics pollution of sea bottoms, not so much of images of plastics-entangled seagulls –suggesting some cultural insensitivity about animals in Spain. Men would be more sensitive than women to this intervention, perhaps because women are already adopting R behaviours and do not have much space for improvement.

vii) Due to differences between countries and genders found in the studies of this Thesis, new research needs include a wider cross-cultural perspective, investigation on different cultural dimensions, and to increase the gender perspective in further psychosocial studies.

Conclusiones

i) Las discrepancias entre los artículos prospectivos y las revisiones analizadas en el Estudio 1 revelaron que, mientras la mayoría de los estudios psicosociales sobre la crisis del microplástico están enfocados en los consumidores individuales, las soluciones que se identifican en los artículos prospectivos se refieren a cambios profundos en a nivel macro (leyes, normativas) y en la organización social y productiva (nivel meso), enfocándose en cambio en la economía circular.

ii) A partir de 17 artículos publicados hasta 2021 y meta-analizados en el Estudio 2, el principal factor psicosocial que se ha investigado para tratar la crisis del microplástico es el conocimiento. El principal marco psicosocial es la Teoría de la Acción razonada junto con la del Valor-Creencia-Norma. A nivel geográfico, los países africanos y latinoamericanos tienen un importante déficit de estudios en este campo.

iii) El análisis de los periódicos más leídos en Canadá, México y España en el Estudio 3 mostró diferencias significativas entre países respecto a las palabras empleadas en noticias sobre microplásticos, más enfocadas en las soluciones en Canadá, las amenazas en México y los actores en España. Según las diferentes dimensiones culturales, el contenido emocional de los términos relevantes sobre microplásticos fue más positivo en Canadá, neutro en España y negativo en México.

iv) En el Estudio 4, la dimensión psicosocial de la ciudadanía marina estudiada, que fue el sentimiento de responsabilidad por el océano, se asoció significativamente con la intención de reducir el consumo de plástico de un solo uso y de reciclar, en México y en España; por el contrario, la frecuentación del mar incluyó, significativamente, en la conducta real de reciclaje, sugiriendo una desconexión entre los componentes de la ciudadanía marina. Según las normas sociales respectivas, los mexicanos adoptarían conductas sostenibles con más frecuencia que los participantes españoles en este estudio.

v) Aunque su conocimiento sobre microplásticos era menor, los participantes mexicanos en el Estudio 5 declararon una conducta y una intención de conducta más sostenibles que los españoles respecto al consumo de microplásticos. Esto concuerda con una legislación más estricta sobre plásticos en México y sugiere la eficacia de enfoques de arriba hacia abajo en este tema.

vi) La exposición online a *nugdes* en el Estudio 6 reveló un efecto significativo de imágenes de pescado contaminado con microplásticos y de contaminación con plástico en los fondos marinos, siendo menor el de imágenes de gaviotas estranguladas con plástico y sugiriendo insensibilidad cultural hacia los animales en España. Los hombres fueron más sensibles a esta intervención que las mujeres, quizás porque ellas ya estaban adoptando conductas R y no tenían mucho espacio de mejora.

vii) Por las diferencias entre países y géneros encontradas en los estudios de esta Tesis se proponen nuevas necesidades de investigación, que incluirían una perspectiva intercultural más amplia, investigación sobre diferentes dimensiones culturales, y fomentar la perspectiva de género en futuros estudios psicosociales.

REFERENCES

Abalansa, S., El Mahrad, B., Vondolia, G. K., Icely, J., & Newton, A. (2020). The marine plastic litter issue: A social-economic analysis. *Sustainability, 12*, 8677. https://doi.org/10.3390/su12208677.

Abate, T. G., Börger, T., Aanesen, M., Falk-Andersson, J., Wyles, K. J., & Beaumont, N. (2020). Valuation of marine plastic pollution in the European Arctic: Applying an integrated choice and latent variable model to contingent valuation. *Ecological Economics, 169*, 106521. https://doi.org/10.1016/j.ecolecon.2019.106521

Abel, S. M., Primpke, S., Int-Veen, I., Brandt, A., & Gerdts, G. (2021). Systematic identification of microplastics in abyssal and hadal sediments of the Kuril Kamchatka trench. *Environmental Pollution, 269*, 116095. https://doi.org/10.1016/j.envpol.2020.116095.

Abrokwah, S., Ekumah, B., Adade, R., & Akuoko, I. S. G. (2021). Drivers of single-use plastic waste generation: lessons from packaged water consumers in Ghana. *GeoJournal 2021*. https://doi.org/10.1007/s10708-021-10390-w

Adam, I., Walker, T. R., Bezerra, J. C., & Clayton, A. (2020). Policies to reduce single-use plastic marine pollution in West Africa. *Marine Policy, 116*, 103928 https://doi.org/10.1016/j.marpol.2020.103928

Adeyanju, G.C., Augustine, T.M., Volkmann, S., Oyebamiji, U. A., Ran, S., Osobajo, O. A., & Otitoju, A. (2021). Effectiveness of intervention on behaviour change against use of non-biodegradable plastic bags: a systematic review. *Discover Sustainability, 2*, 13. https://doi.org/10.1007/s43621-021-00015-0

Ahmed, R., Hamid, A. K., Krebsbach, S. A., He, J., & Wang, D. (2022). Critical review of microplastics removal from the environment. *Chemosphere, 293*, 133557, https://doi.org/10.1016/j.chemosphere.2022.133557.

Ajith, N., Arumugam, S., Parthasarathy, S., Manupoori, S., & Sivamani Janakiraman, S. (2020). Global distribution of microplastics and its impact on marine environment—a review. *Environmental Science and Pollution Research, 27*, 25970-25986. https://doi.org/10.1007/s11356-020-09015-5

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211. https://doi.org/10.1016/0749-5978(91)90020-t

Ajzen, I. (2002). Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. *Journal of Applied Social Psychology, 32*(4), 665-683.

Ajzen, I., & Fishbein, M. (1980). *Understanding Attitudes and Predicting Social Behavior*. Prentice-Hall. Englewood Cliffs, NJ.

Ajzen, I., & Madden, T. (1986). Prediction of goal-directed behavior: attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology, 22*, 453-474.

Albrecht, S. L., Bocks, A., Dalton, J., Lorigan, A., & Smith, A. (2021). Pro-Environmental employee engagement: The influence of pro-environmental organizational, job and personal resources. *Sustainability, 14*(1), 43. https://doi.org/10.3390/su14010043.

Alimi, O. S., Fadare, O. O., & Okoffo, E. D. (2021). Microplastics in African ecosystems: Current knowledge, abundance, associated contaminants, techniques, and research needs. *Science of the Total Environment, 755*, 142422. https://doi.org/10.1016/j.scitotenv.2020.142422.

All European Academies (2017). *The European Code of Conduct for Research Integrity*. Berlin-Brandenburg Academy of Sciences and Humanities, Berlin.

Anagnosti, L., Varvaresou, A., Pavlou, P., Protopapa, E., & Carayanni, V. (2021). Worldwide actions against plastic pollution from microbeads and microplastics in cosmetics focusing on European policies. Has the issue been handled effectively? *Marine Pollution Bulletin, 162*, 111883. https://doi.org/10.1016/j.marpolbul.2020.111883

Anderson, A. G., Grose, J., Pahl, S., Thompson, R. C., & Wyles, K. J. (2016). Microplastics in personal care products: Exploring perceptions of environmentalists, beauticians, and students. *Marine Pollution Bulletin, 113*, 454-460. https://doi.org/10.1016/j.marpolbul.2016.10.048.

Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin, 62*(8), 1596-1605. https://doi.org/10.1016/j.marpolbul.2011.05.030.

Andrade, G. E. (2022). A response to cultural arguments in the renewed disputes over the ethics of bullfighting. *Sport, Ethics and Philosophy, 16*(1), 50-65, https://doi.org/10.1080/17511321.2021.188733

Angnunavuri, P. N., Attiogbe, F., & Mensah, B. (2020). Consideration of emerging environmental contaminants in Africa: Review of occurrence, formation, fate, and toxicity of plastic particles. *Scientific African, 9*, e00546. https://doi.org/10.1016/j.sciaf.2020.e00546

Ardura, A., Dopico, E., Fernandez, S., & Garcia-Vazquez, E. (2021). Citizen volunteers detect SARS-CoV-2 RNA from outdoor urban fomites. *Science of the Total Environment, 787*, 147719. https://doi.org/10.1016/j.scitotenv.2021.147719.

Arnocky, S., Stroink, M., & DeCicco, T. (2007). Self-construal predicts environmental concern, cooperation, and conservation. *Journal of Environmental Psychology, 27*, 255-264. https://doi.org/10.1016/j.jenvp.2007.06.005.

Asih, D., Setini, M., Soelton, M., Muna, N., Putra, I. G. P., Darma, D. C., & Judiarni, J. A. (2020). Predicting green product consumption using theory of planned behavior and reasoned action. *Management Science Letters, 10*, 3367–3374. https://doi.org/10.5267/j.msl.2020.5.042

Aslam, F., Awan, T.M., Syed, J.H., Kashif, A., & Parveen. M. (2020). Sentiments and emotions evoked by news headlines of coronavirus disease (COVID-19) outbreak. *Humanities and Social Sciences Communications, 7*, 23. https://doi.org/10.1057/s41599-020-0523-3.

Auta, H. S., C.U. Emenike, C. U., & Fauziah, S. H. (2017). Distribution and importance of microplastics in the marine environment: a review of the sources, fate, effects, and potential solutions. *Environment International, 102*, 165-176. https://doi.org/10.1016/j.envint.2017.02.013

Ballantyne, A. G., de Cros Péronard, J-P., Hansen, R.A., & Gross, A. (2021). Media issue crystallization: the case of microplastic in Denmark. *Environmental Communication, 15*(5), 610-624. https://doi.org/10.1080/17524032.2021.1877761

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes, 50*(2), 248–287. https://doi.org/10.1016/0749-5978(91)90022-L

Barboza, L.G.A., Vethaak, A.D., Lavorante, B.R.B.O., Lundebye, A-K., & Guilhermino, L. (2018). Marine microplastic debris: An emerging issue for food security, food safety and human health. *Marine Pollution Bulletin, 133*, 336-348. https://doi.org/10.1016/j.marpolbul.2018.05.047

Barboza, L. G. A., Lopes, C., Oliveira, P., Bessa, F., Otero, V., Henriques, B., Raimundo, J., Caetano, M., Vale, C., and Guilhermino, L. (2020). Microplastics in wild fish from North East Atlantic Ocean and its potential for causing neurotoxic effects, lipid oxidative damage, and human health risks associated with ingestion exposure. *Science of the Total Environment, 717*, 134625, https://doi.org/10.1016/j.scitotenv.2019.134625

Bator, R. J., Bryan, A. D., & Wesley Schultz, P. (2011). Who gives a hoot?: Intercept surveys of litterers and disposers. *Environmental Behavior, 43*(3), 295-315. https://doi.org/10.1177/0013916509356884

Baum, M.A., & Potter, P.B.K. (2008). The relationships between mass media, public opinion, and foreign policy: Toward a theoretical synthesis. *Annual Review of Political Science, 11*(1), 39-65. https://doi.org/10.1146/annurev.polisci.11.060406.214132

Berenguer, J. (2007). The effect of empathy in proenvironmental attitudes and behaviors. *Environment and Behavior, 39*(2), 269-283. https://doi.org/10.1177/0013916506292937.

Bergmann, M., Mützel, S., Primpke, S., Tekman, M. B., Trachsel, J., & Gerdts, G. (2019). White and wonderful? Microplastics prevail in snow from the Alps to the Arctic. *Science Advances, 5*, eaax1157. https://doi.org/1126/sciadv.aax1157

Bettini, G. (2013). Climate Barbarians at the Gate? A critique of apocalyptic narratives on 'climate refugees'. *Geoforum, 45*, 63-72. https://doi.org/10.1016/j.geoforum.2012.09.009.

Bhanot, S. P. (2021). Isolating the effect of injunctive norms on conservation behavior: New evidence from a field experiment in California. *Organizational Behavior and Human Decision Processes, 163*, 30-42. https://doi.org/10.1016/j.obhdp.2018.11.002.

Borg, K., Lennox, A., Kaufman, S., Tull, F., Prime, R., Rogers, L., & Dunstan, E. (2022). Curbing plastic consumption: A review of single-use plastic behaviour change interventions. *Journal of Cleaner Production, 344*, 131077. https://doi.org/10.1016/j.jclepro.2022.131077

Borrelle, S.B., Ringma, J., Law, K.L., Monnahan, C.C., Lebreton, L., Mcgivern, A., Murphy, E., Jambeck, J., Leonard, G.H., Hilleary, M.A., Eriksen, M., Possingham, H.P., de Frond, H., Gerber, L.R., Polidoro, B., Tahir, A., Bernard, M., Mallos, N., Barnes, M., & Rochman, C.M. (2020). Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. *Science, 369*(6510), 1515-1518. https://doi.org/10.1126/science.aba3656

Brachner, A., Fragouli, D., Duarte, I.F., Farias, P.M.A., Dembski, S., Ghosh, M., Barisic, I., Zdzieblo, D., Vanoirbeek, J., Schwabl, P., & Neuhaus, W. (2020). Assessment of human health risks posed by nano- and microplastics is currently not feasible. *International Journal of Environmental Research and Public Health, 17*, 8832. https://doi.org/10.3390/ijerph17238832.

Bradley, G. L., Babutsidze, Z., Chai, A., & Reser, J. P. (2020). The role of climate change risk perception, response efficacy, and psychological adaptation in pro-environmental behavior: A two nation study. *Journal of Environmental Psychology, 68*, 101410, https://doi.org/10.1016/j.jenvp.2020.101410

Bravo, M., Gallardo, M. A., Luna-Jorquera, G., Núñez, P., Vásquez, N., & Thiel, M. (2009). Anthropogenic debris on beaches in the SE Pacific (Chile): Results from a national survey supported by volunteers. *Marine Pollution Bulletin, 58*(1), 1718-1726. https://doi.org/10.1016/j.marpolbul.2009.06.017

Bronfman, N.C., Cisternas, P.C., López-Vázquez, E., Maza, C.D.l., & Oyanedel, J.C. (2015). Understanding attitudes and pro-environmental behaviors in a Chilean community. *Sustainability, 7*, 14133-14152. https://doi.org/10.3390/su71014133.

Bundhoo, Z. M. A. (2018). Solid waste management in least developed countries: current status and challenges faced. *Journal of Material Cycles and Waste Management, 20*, 1867-1877. https://doi.org/10.1007/s10163-018-0728-3.

Burrows, S. D., Ribeiro, F., O'Brien, S., Okoffo, E., Toapanta, T., Charlton, N., Kaserzon, S., Lin, C-Y., Tang, C., Rauert, C., Wang, X., Shimko, K., O'Brien, J., Townsend, P.A., Grayson, M.N., Galloway, T., & Thomas, K.V. (2022). The message on the bottle: Rethinking plastic labelling to better encourage sustainable use. *Environmental Science & Policy, 132*, 109-118. https://doi.org/10.1016/j.envsci.2022.02.015

Byerly, H., Balmford, A., Ferraro, P. J., Wagner, C. H., Palchak, E., Polasky, S., Ricketts, T. H., Schwartz, A. J., & Fisher, B. (2018). Nudging pro-environmental behavior: evidence and opportunities. *Frontiers in Ecology and the Environment, 16*(3), 159-168. https://doi.org/10.1002/fee.1777

Cammalieri, V., Marotta, D., Antonucci, A., Protano, C., & Fara, G. M. (2020). A survey of knowledge & awareness on the issue "microplastics": a pilot study in a sample of future public health professionals. *Annali di Igiene, 32*(5), 577-589. https://doi.org/10.1007/978-3-319-61615-5_11

Campanale, C., Massarelli, C., Savino, I., Locaputo, V., & Uricchio, V.F. (2020). A detailed review study on potential effects of microplastics and additives of concern on human health. *International Journal of Environmental Research and Public Health, 17*, 1212. https://doi.org/10.3390/ijerph17041212

Cappa, F., Rosso, F., Giustiniano, L., & Porfiri, M. (2020). Nudging and citizen science: The effectiveness of feedback in energy-demand management. *Journal of Environmental Management*, *269*, 110759. https://doi.org/10.1016/j.jenvman.2020.110759

Carroll, C., Sousa, J., and Thevenon, F. (2014). *Plastic debris in the ocean: the characterization of marine plastics and their environmental impacts, situation analysis report*. International Union for the Conservation of Nature, 52 pp. Gland, CH https://doi.org/10.2305/IUCN.CH.2014.03.en.

Carrus, G., Passafaro, P., & Bonnes, M. (2008). Emotions, habits and rational choices in ecological behaviours: The case of recycling and use of public transportation. *Journal of Environmental Psychology, 28*(1), 51-62, https://doi.org/10.1016/j.jenvp.2007.09.003.

Catarino, A. I., Kramm, J., Völker, C., Henry, T. B., & Everaert, G. (2021). Risk posed by microplastics: Scientific evidence and public perception. *Current Opinion in Green and Sustainable Chemistry*, *29*, 100467. https://doi.org/10.1016/j.cogsc.2021.100467

Chang, M. (2015). Reducing microplastics from facial exfoliating cleansers in wastewater through treatment versus consumer product decisions. *Marine Pollution Bulletin*, *101*(1), 330-333. https://doi.org/10.1016/j.marpolbul.2015.10.074

Charitou, A., Aga-Spyridopoulou, R. N., Mylona, Z., Beck, R., McLellan, F., & Addamo, A. M. (2021). Investigating the knowledge and attitude of the Greek public towards marine plastic pollution and the EU Single-Use Plastics Directive. *Marine Pollution Bulletin*, *166*, 112182. https://doi.org/10.1016/j.marpolbul.2021.112182.

Chassignet, E. P., Xu, X., & Zavala-Romero, O. (2021). Tracking marine litter with a global ocean model: Where does it go? Where does it come from? *Frontiers in Marine Science*, *8*, 667591. https://doi.org/10.3389/fmars.2021.667591

Chen, M. F. (2015). An examination of the value-belief-norm theory model in predicting pro-environment behavior in Taiwan. *Asian Journal of Social Psychology*, *18*, 145-151.

Chen, G., Feng, Q., & Wang, J. (2020). Mini-review of microplastics in the atmosphere and their risks to humans. *Science of the Total Environment, 703*, 135504, https://doi.org/10.1016/j.scitotenv.2019.135504.

Chen, J., Wu, J., Sherrell, P. C., Chen, J., Wang, H., Zhang, W., & Yang, J. (2022). How to build a microplastics-free environment: Strategies for microplastics degradation and plastics recycling. *Advanced Science, 9*, 2103764. https://doi.org/10.1002/advs.202103764

Chen, Y., Awasthi, A. K., Wei, F., Tan, Q., & Li, J. (2021). Single-use plastics: Production, usage, disposal, and adverse impacts. *Science of the Total Environment*, *752*, 141772. https://doi.org/10.1016/j.scitotenv.2020.141772

Cho, E. (2020). A comprehensive review of so-called Cronbach's alpha. *Journal of Production Research*, *38*(1), 9–20. doi:10.36345/KACST.2020.38.1.002.

Choi, E. C., & Lee, J. S. (2018). The willingness to pay for removing the microplastics in the ocean - The case of Seoul metropolitan area, South Korea. *Marine Policy, 93*, 93-100. https://doi.org/10.1016/j.marpol.2018.03.015.

Corona, E., Martin, C., Marasco, R., & Duarte, C. M. (2020). Passive and active removal of marine microplastics by a mushroom coral (*Danafungia scruposa*). *Frontiers in Marine Science*, *7*, 128. doi: 10.3389/fmars.2020.00128.

Costa, S., & Caldeira, R. (2018). Bibliometric analysis of ocean literacy: an underrated term in the scientific literature. *Marine Policy, 87*, 149-157. http://dx.doi.org/10.1016/j.marpol.2017.10.022.

Cottle, S. (2009). Global crises in the news: Staging new wars, disasters, and climate change. *International Journal of Communication*, *3*, 24.

Cox, K. D., Covernton, G. A., Davies, H. L., Dower, J. F., Juanes, F., & Dudas, S. E. (2019). Human consumption of microplastics. *Environmental Science & Technology*, *53*(12), 7068-7074. https://doi.org/10.1021/acs.est.9b01517.

D'Angelo, S., & Meccariello, R. (2021). Microplastics: A threat for male fertility. *International Journal of Environmental Research and Public Health*, *18*(5), 2392. https://doi.org/10.3390/ijerph18052392.

Da Costa, J. P., Mouneyrac, C., Costa, M., Duarte, A. C., & Rocha-Santos, T. (2020). The role of legislation, regulatory initiatives and guidelines on the control of plastic pollution. *Frontiers in Environmental Science, 8*, 104. https://doi.org/10.3389/fenvs.2020.00104.

Damsbo-Svendsen, S. (2022). Mass media influence on the rapid rise of climate change. *International Journal of Public Opinion Research, 34*(2), edac009. https://doi.org/10.1093/ijpor/edac009.

Dauvergne, P. (2018). The power of environmental norms: marine plastic pollution and the politics of microbeads. *Environmental Politics, 27*(4), 579-597. http://dx.doi.org/10.1080/09644016.2018.1449090.

De Falco, F., Di Pace, E., Cocca, M., & Avella, M. (2019). The contribution of washing processes of synthetic clothes to microplastic pollution. *Scientific Reports, 9*, 6633. https://doi.org/10.1038/s41598-019-43023-x.

De Groot, J.I.M., Abrahamse, W., and Jones, K. (2013). Persuasive normative messages: The influence of injunctive and personal norms on using free plastic bags. Sustainability 5, 1829-1844. https://doi.org/10.3390/su5051829

De-la-Torre, G.E. (2020). Microplastics: an emerging threat to food security and human health. *Journal of Food Science and Technology, 57*, 1601-1608. https://doi.org/10.1007/s13197-019-04138-1

Deme, G. G., Ewusi-Mensah, D., Olagbaju, O. A., Okeke, E. S., Okoye, C. O., Odii, E. C., ... & Sanganyado, E. (2022). Macro problems from microplastics: Toward a sustainable policy framework for managing microplastic waste in Africa. *Science of the Total Environment, 804*, 150170. https://doi.org/10.1016/j.scitotenv.2021.150170

Deng, J., Walker, G. J., & Swinnerton, G. (2006). A comparison of environmental values and attitudes between Chinese in Canada and Anglo-Canadians. *Environment and Behavior, 38*(1), 22-47. https://doi.org/10.1177/0013916505278458.

Deng, L., Cai, L., Sun, F., Li, G., & Che, Y. (2020). Public attitudes towards microplastics: Perceptions, behaviors, and policy implications. *Resources, Conservation and Recycling, 163*, 105096. https://doi.org/10.1016/j.resconrec.2020.105096

Didarali, Z., Kuiper, T., Brink, C. W., Buij, R., Virani, M. Z., Reson, E. O., & Santangeli, A. (2022). Awareness of environmental legislation as a deterrent for wildlife crime: A case with Masaai pastoralists, poison use and the Kenya Wildlife Act. *Ambio, 51*(7), 1632-1642.

Didegah, F., Mejlgaard, N., & Sørensen, M. P. (2018). Investigating the quality of interactions and public engagement around scientific papers on Twitter. *Journal of Informetrics, 12*, 960-971. https://doi.org/10.1016/j.joi.2018.08.002.

Dijkstra, H., van Beukering, P., & Brouwer, R. (2020). Business models and sustainable plastic management: A systematic review of the literature. *Journal of Cleaner Production, 258*, 120967, https://doi.org/10.1016/j.jclepro.2020.120967.

Dilkes-Hoffman, L., Ashworth, P., Laycock, B., Pratt, S., and Lant, P. (2019a). Public attitudes towards bioplastics - Knowledge, perception, and end-of-life management. Res. Cons. Recycling 151, 104479. https://doi.org/10.1016/j.resconrec.2019.104479

Dilkes-Hoffman, L. S., Pratt, S., Laycock, B., Ashworth, P., and Lant, P. A. (2019b). Public attitudes towards plastics. Res. Cons. Recycling 147, 227-235. https://doi.org/10.1016/j.resconrec.2019.05.005

Do Paço, A., Alves, H., Shiel, C., & Filho W.L. (2013) A multi-country level analysis of the environmental attitudes and behaviours among young consumers. *Journal of Environmental Planning and Management, 56*(10), 1532-1548, https://doi.org/10.1080/09640568.2012.733310.

Dolzhenko, I. B., & Churakova, A. A. (2022). Environmental Responsibility of Fashion Industry Multinational Corporations (MNCs) in the Context of Industry 4.0. In *Industry 4.0: Fighting Climate Change in the Economy of the Future* (pp. 79-89). Cham: Springer International Publishing.

Dopico, E., Arboleya, E., Fernandez, S., Borrell, Y., Consuegra, S., García de Leaniz, C., Lázaro, G., Rodríguez, C., & Garcia-Vazquez, E. (2022). Water security determines

social attitudes about dams and reservoirs in South Europe. *Scientific Reports, 12*, 6148. https://doi.org/10.1038/s41598-022-10170-7.

Engel, M. T., Vaske, J. J., & Bath, A. J. (2021). Ocean imagery relates to an individual's cognitions and pro-environmental behaviours. *Journal of Environmental Psychology, 74*, 101588. https://doi.org/10.1016/j.jenvp.2021.101588.

Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Galgani, F., Ryan, P. G., & Reisser, J. (2014). Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. *PLoS ONE, 9*(12), e111913. https://doi.org/10.1371/journal.pone.0111913

Eriksen, M., Thiel, M., Prindiville, M., & Kiessling, T. (2018). Microplastic: What Are the Solutions? In Wagner M., Lambert S. (Eds.) *Freshwater Microplastics*. The Handbook of Environmental Chemistry, vol 58, pp. 273-298. Springer, Cham. https://doi.org/10.1007/978-3-319-61615-5_11.

Escario, J.-J., Rodriguez-Sanchez, C., & Casaló, L. V. (2020). The influence of environmental attitudes and perceived effectiveness on recycling, reducing, and reusing packaging materials in Spain. *Waste Management, 113*, 251-260. https://doi.org/10.1016/j.wasman.2020.05.043

European Commission (2018). *Communication from the Commission: A European Strategy for Plastics in a Circular Economy – Strategy*, COM/2018/028 final, Document 52018DC0028 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:28:FIN#footnote16

European Union (2019). *Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment*, 2019.

Fantke, P., de Bruin, Y. B., Schlüter, U., Connolly, A., Bessems, J., Kephalopoulos, S., Jeddi, M. Z., van Nieuwenhuyse, A., Dudzina, T., Scheepers, P. T. J., & von Goetz, N. (2022). The European exposure science strategy 2020-2030. *Environment International, 170*, 107555. https://doi.org/10.1016/j.envint.2022.107555.

Farady, S. E. (2019). Microplastics as a new, ubiquitous pollutant: Strategies to anticipate management and advise seafood consumers. *Marine Policy, 104*, 103-107. https://doi.org/10.1016/j.marpol.2019.02.020.

Felipe-Rodriguez, M., Böhm, G., & Doran, R. (2022). What does the public think about microplastics? Insights from an empirical analysis of mental models elicited through free associations. *Frontiers in Psychology, 13*, 920454. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.920454

Ferreira, G. V. B., Barletta, M., Lima, A. R. A., Morley, S. A., Justino, A. K. S., & Costa, M. F. (2018). High intake rates of microplastics in a Western Atlantic predatory fish, and insights of a direct fishery effect. *Environmental Pollution, 236*, 706-717. https://doi.org/10.1016/j.envpol.2018.01.095.

Ferreira, J.C., Vasconcelos, L., Monteiro, R., Silva, F.Z., Duarte, C.M., & Ferreira, F. (2021). Ocean literacy to promote sustainable development goals and agenda 2030 in coastal communities. *Education Sciences, 11*(2), 62. https://doi.org/10.3390/educsci11020062.

Fishbein, M., and Ajzen, I. (1975). Belief, Attitude, Intention, and Behavior: an introduction to theory and research. Addison-Wesley, Reading, MA.

Fletcher, S. and Potts, J. (2007). Ocean citizenship: An emergent geographical concept. Coastal Manage. 35(4), 511–524. https://doi.org/10.1080/08920750701525818

Freeman, S., Booth, A. M., Sabbah, I., Tiller, R., Dierking, J., Klun, K., Rotter, A., Ben-David, E., Javidpour J., & Angel, D. L. (2020). Between source and sea: The role of wastewater treatment in reducing marine microplastics. *Journal of Environmental Management, 266*, 110642. https://doi.org/10.1016/j.jenvman.2020.110642.

Galbreath, J. (2019). Drivers of green innovations: The impact of export intensity, women leaders, and absorptive capacity. *Journal of Business Ethics, 158*, 47-61.

Gall, S. C., & Thompson, R. C. (2015). The impact of debris on marine life. *Marine Pollution Bulletin, 92*, 170-179. https://doi.org/10.1016/j.marpolbul.2014.12.041

Gamson, W.A., & Modigliani, A. (1989). Media discourse and public opinion on nuclear power: A constructionist approach. *American Journal of Sociology, 95*(1), 1-37. https://www.jstor.org/stable/2780405.

Gao, Y., & Liu, Y. (2022). Removal of microplastics by coagulation treatment in waters and prospect of recycling of separated microplastics: A mini-review. *Journal of Environmental Chemical Engineering, 10*(5), 108197. https://doi.org/10.1016/j.jece.2022.108197

García-Gallego, A., Borrell, Y.J., & Miralles, L. (2021). The future of marine citizenship is now: Cetacean conservation in the eyes of young Spanish citizens. *Aquatic Conservation, 31*(11), 3146– 3155. https://doi.org/10.1002/aqc.3696

Garcia-Vazquez, E., Carton, P., Dominguez, M., Rodriguez, N., Bustillos, A., & Dopico, E. (2021). *For a good selfie*. Enhancing mobile phone recycling through simulated exposure to cobalt mining. *Sustainable Production and Consumption, 26*, 44-53. https://doi.org/10.1016/j.spc.2020.09.012

Garcia-Vazquez, E., & Garcia-Ael, C. (2021). The invisible enemy. Public knowledge of microplastics is needed to face the current microplastics crisis. *Sustainable Production and Consumption, 28*, 1076-1089. https://doi.org/10.1016/j.spc.2021.07.032.

Garcia-Vazquez, E., Garcia-Ael, C., Dopico, E., Rodríguez Fernández, N., & Librada, M. (2022). Knowledge and attitudes about microplastics. *Mendeley Data*, V1, https://doi.org/10.17632/9bzcw5yrpx.1.

Garcia-Vazquez, E., Garcia-Ael, C., Mesa, M.L.C., Dopico, E., & Rodriguez N. (2022). Enhancing marine citizenship as a strategy to promote the reduction of single-use plastics consumption in different cultures. *Frontiers in Marine Science, 9*, 941694. https://doi.org/10.3389/fmars.2022.941694

Garcia-Vazquez, E., Garcia-Ael, C., Mesa, M.L.C., Rodriguez, N., & Dopico, E. (2023). Greater willingness to reduce microplastics consumption in Mexico than in Spain supports the importance of legislation about the use of plastics. *Frontiers in Psychology, 13*, 1027336. https://doi.org/10.3389/fpsyg.2022.1027336

Gasperi, J., Wright, S. L., Dris, R., Collard, F., Mandin, C., Guerrouache, M., Langlois, V., Kelly, F. J., and Tassin, B. (2018). Microplastics in air: Are we breathing it in? *Current Opinion in Environmental Sciences and Health, 1*, 1-5, https://doi.org/10.1016/j.coesh.2017.10.002.

Gerbner, G., Gross, L., Morgan, M., Signorielli, N., & Shanahan, J. (2002). Growing up with television: Cultivation processes. *Media effects: Advances in theory and research, 2*, 43-67.

Gibovic, D., & Bikfalvi, A. (2021). Incentives for plastic recycling: How to engage citizens in active collection. Empirical evidence from Spain. *Recycling, 6*, 29. https://doi.org/10.3390/recycling6020029

Gill, M. B., Jensen, K. L., Lambert, D.M., Upendram, S., English, B. C., Labbé, N., Jackson, S. W., & Menard, R. J. (2020). Consumer preferences for eco-friendly attributes in disposable dinnerware. *Resources, Conservation and Recycling, 161*, 104965. https://doi.org/10.1016/j.resconrec.2020.104965

Giri, S. (2021). Water quality prospective in Twenty First Century: Status of water quality in major river basins, contemporary strategies and impediments: A review. *Environmental Pollution, 271*, 116332. https://doi.org/10.1016/j.envpol.2020.116332.

Gola, D., Tyagi, P. K., Arya, A., Chauhan, N., Agarwal, M., Singh, S. K., and Gola, S. (2021). The impact of microplastics on marine environment: A review. *Environmental Nanotechnology for Monitoring and Management, 16*, 100552, https://doi.org/10.1016/j.enmm.2021.100552

Grant, M.L., Lavers, J.L., Hutton, I., & Bond, A.L. (2021). Seabird breeding islands as sinks for marine plastic debris. *Environmental Pollution, 276*, 116734. https://doi.org/10.1016/j.envpol.2021.116734

Grünzner, M., & Pahl, S. (2023). Behavior Change as Part of the Solution for Plastic Pollution. In: *Living in the Plastic Age. Perspectives from Humanities, Social*

Sciences and Natural Sciences, eds. J. Kramm & C. Völker. Campus Verlag, Frankfurt.

Guest, H., Lotze, H. K., & Wallace, D. (2015). Youth and the sea: Ocean literacy in Nova Scotia, Canada. *Marine Policy, 58*, 98-107. https://doi.org/10.1016/j.marpol.2015.04.007

Hale, R. C., Seeley, M. E., La Guardia, M. J., Mai, L., & Zeng, E. Y. (2020). A global perspective on microplastics. *Journal of Geophysical Research: Oceans, 125*, e2018JC014719. https://doi.org/10.1029/2018JC014719

Hamidian, A. H., Ozumchelouei, E. J., Feizi, F., Wu, C., Zhang, Y., & Yang, M. (2021). A review on the characteristics of microplastics in wastewater treatment plants: A source for toxic chemicals. *Journal of Cleaner Production, 295*,126480. https://doi.org/10.1016/j.jclepro.2021.126480

Hammer, Ø., Harper, D.A.T., & Ryan, P.D. (2001). PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica, 4*(1), 9. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Harari, M. B., Parola, H. R., Hartwell, C. J., & Riegelman, M. (2020). Literature searches in systematic reviews and meta-analyses: A review, evaluation, and recommendations. *Journal of Vocational Behavior, 118*, 103377. https://doi.org/10.1016/j.jvb.2020.103377.

Heidbreder, L. M., Bablok, I., Drews, S., and Menzel, C. (2019). Tackling the plastic problem: a review on perceptions, behaviors, and interventions. Sci. Total Environ. 668, 1077-1093. https://doi.org/10.1016/j.scitotenv.2019.02.437

Heidbreder, L. M., Steinhorst, J., and Schmitt, M. (2020). Plastic-Free July: An experimental study of limiting and promoting factors in encouraging a reduction of single-use plastic consumption. Sustainability 12(4698), 46. https://doi.org/10.3390/su12114698

Heller, M.C., Mazor, M.H., & Keoleian, G.A. (2020). Plastics in the US: toward a material flow characterization of production, markets, and end of life. *Environmental Research Letters, 15*(9), 094034. https://doi.org/10.1088/1748-9326/ab9e1e

Henderson, L., & Green, C. (2020). Making sense of microplastics? Public understandings of plastic pollution. *Marine Pollution Bulletin, 152*, 110908. https://doi.org/10.1016/j.marpolbul.2020.110908.

Herweyers, L., Catarci Carteny, C., Scheelen, L., Watts, R., & Du Bois, E. (2020). Consumers' perceptions and attitudes toward products preventing microfiber pollution in aquatic environments as a result of the domestic washing of synthetic clothes. *Sustainability, 12*, 2244. https://doi.org/10.3390/su12062244

Hines, J.M., Hungerford, H.R., and Tomera, A.N. (1986–87). Analysis and synthesis of researchon responsible pro-environmental behavior: a meta-analysis. *Journal of Environmental Education, 18*(2), 1-8.

Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). *Cultures and Organizations: Software of the Mind*. *Intercultural Cooperation and Its Importance for Survival*. McGraw Hill. ISBN: 978-0-07-177015-6.

Howell, R.A. (2014). Using the transtheoretical model of behavioural change to understand the processes through which climate change films might encourage mitigation action. *International Journal of Sustainable Development, 17*(2), 137-159. https://doi.org/10.1504/IJSD.2014.061778.

Hu, D., Shen, M., Zhang, Y., & Zeng, G. (2019). Micro(nano)plastics: an un-ignorable carbon source? *Science of the Total Environment, 657*, 108-110. https://doi.org/10.1016/j.scitotenv.2018.12.046

Hu, E., Stavropoulos, V., Anderson, A., Clarke, M., Beard, C., Papapetrou, S., & Gomez, R. (2019). Assessing online Flow across cultures: A two-fold measurement invariance study. *Frontiers in Psychology*, *10*, 407. https://doi.org/10.3389/fpsyg.2019.00407.

Hunt, C. F., Lin, W. H., & Voulvoulis, N. (2021). Evaluating alternatives to plastic microbeads in cosmetics. *Nature Sustainability*, *4*(4), 366-372. https://doi.org/10.1038/s41893-020-00651-w.

IPSOS/Plastic Free July (2022). *Attitudes towards single use plastics*. Game Changers IPSOS, available at https://www.ipsos.com/sites/default/files/ct/news/documents/2022-02/Attitudes-towards-single-use-plastics-Feb-2022.pdf, accessed on June 2022.

ISCED (2011). *International Standard Classification of Education*. UNESCO Institute for Statistics, Montreal, Quebec. ISBN 978-92-9189-123-8.

Jackson, D. N., Guthrie, G. M., Astilla, E., & Elwood, B. (1983). The cross-cultural generalizability of personality construct measures. In J. W. Berry, & S. H. Irvine (Eds.), *Human assessment and cultural factors* (NATO Conference Series ed., pp. 365-375). Springer.

Jacobsen, L. F., Pedersen, S., & Thøgersen, J. (2022). Drivers of and barriers to consumers' plastic packaging waste avoidance and recycling – A systematic literature review. *Waste Management, 141*, 63-78. https://doi.org/10.1016/j.wasman.2022.01.021.

Jakovcevic, A., L. Steg, L., N. Mazzeo, N., R. Caballero, R., P. Franco, P., N. Putrino, N., & Favara, J. (2014). Charges for plastic bags: Motivational and behavioral effects. *Journal of Environmental Psychology, 40*, 372–380. https://doi.org/10.1016/j.jenvp.2014.09.004

Jambeck, J., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R., & Law, K.L. (2015). Plastic waste inputs from land into the ocean. *Science, 347*, 768-771. https://doi.org/10.1126/science.1260352

Janouskova, S., Teplý, P., Fatka, D., Teplá, M., Cajthaml, T., & Hák, T. (2020). Microplastics—How and what do university students know about the emerging environmental sustainability issue? *Sustainability, 12*, 9220. https://doi.org/10.3390/su12219220.

Jarić, I., Courchamp, F., Correia, R. A., Crowley,S. L., Essl, F., Fischer, A., et al. (2020). The role of species charisma in biological invasions. *Frontiers in Ecology and the Environment, 18*(6), 345-353. https://doi.org/10.1002/fee.2195.

JASP Team (2022). *JASP (Version 0.16.3)*[Computer software]. Accessed at https://jasp-stats.org/download/ in October 2022.

Jeong, D., Yoon, A., & Chon, J. (2021). The impact of the perceived risk and conservation commitment of marine microplastics on tourists' pro-environmental behaviors. *Science of the Total Environment, 774*, 144782. https://doi.org/10.1016/j.scitotenv.2020.144782.

Jia, L., Evans, S. & Linden, S.V.D. (2019). Motivating actions to mitigate plastic pollution. *Nature Communications, 10*, 4582. https://doi.org/10.1038/s41467-019-12666-9

Johansen, M.R., Christensen, T.B., Ramos, T.M., & Syberg, K. (2022). A review of the plastic value chain from a circular economy perspective. *Journal of Environmental Management, 302*(A), 113975. https://doi.org/10.1016/j.jenvman.2021.113975

Jovarauskaitė, L., Balundė, A., Truskauskaitė-Kunevičienė, I., Kaniušonytė, G., Žukauskienė, R., & Poškus, M. S. (2020). Toward reducing adolescents' bottled water purchasing: from policy awareness to policy-congruent behavior. *SAGE Open* https://doi.org/10.1177/2158244020983299

Jribi, S., Ben Ismail, H., Doggui, D., & Debbabi, H. (2020). COVID-19 virus outbreak lockdown: What impacts on household food wastage? *Environment, Development and Sustainability*, *22*(5), 3939-3955. https://doi.org/10.1007/s10668-020-00740-y

Karlsson, R. (2012). Individual guilt or collective progressive action? Challenging the strategic potential of Environmental Citizenship Theory. *Environmental Values, 21*, 459-474. https://doi.org/10.2307/41714204

Katsnelson, A. (2015). News Feature: Microplastics present pollution puzzle. *Proceedings of the National Academy of Science USA, 112*(18), 5547-5549. https://doi.org/10.1073/pnas.1504135112.

Keller, A., & Wyles, K. J. (2021). Straws, seals, and supermarkets: Topics in the newspaper coverage of marine plastic pollution. *Marine Pollution Bulletin, 166*, 112211. https://doi.org/10.1016/j.marpolbul.2021.112211.

Kentin, E., & Kaarto, H. (2018). An EU ban on microplastics in cosmetic products and the right to regulate. *Review of European, Comparative & International Environmental Law*, *27*, 254–266. https://doi.org/10.1111/reel.12269.

Khan, F., Ahmed, W., & Najmi, A (2019). Understanding consumers' behavior intentions towards dealing with the plastic waste: perspective of a developing country. *Resources, Conservation & Recycling, 142*, 49-58. https://doi.org/10.1016/j.resconrec.2018.11.020

Kim, A. A., Sadatsafavi, H., Medal, L., & Ostergren, M. J. (2018). Impact of communication sources for achieving campus sustainability. *Resources, Conservation and Recycling, 139*, 366-376. https://doi.org/10.1016/j.resconrec.2018.08.024.

Kirchherr, J., Reike, D., & Hekkert, M.P. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221-232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kitayama, S., Markus, H. R., & Kurokawa, M. (2000). Culture, emotion, and well-being: Good feelings in Japan and the United States. *Cognition & Emotion*, *14*(1), 93-124. https://doi.org/10.1080/026999300379003.

Klingelhöfer, D., Braun, M., Quarcoo, D., Brüggmann, D., & Groneberg, D. A. (2020). Research landscape of a global environmental challenge: Microplastics. *Water Research*, *170*, 115358. https://doi.org/10.1016/j.watres.2019.115358.

Koelmans, A. A., Redondo-Hasselerharm, P. E., Nor, N. H. M., de Ruijter, V. N., Mintenig, S. M., & Kooi, M. (2022). Risk assessment of microplastic particles. *Nature Reviews Materials*, *7*(2), 138-152.

Kollnuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, *8*, 239-260. https://doi.org/10.1080/13504620220145401

Komatsu, H., Rappleye, J., & Silova, I. (20019). Culture and the Independent Self: Obstacles to environmental sustainability?. *Anthropocene, 26*, 100198. https://doi.org/10.1016/j.ancene.2019.100198.

Kramm, J., & Volker, C. (2018). Understanding the risks of microplastics: A social-ecological risk perspective. In Wagner M., Lambert S. (Eds.) *Freshwater Microplastics*. *The Handbook of Environmental Chemistry*, vol. 58, pp. 223-237. Springer, Cham. https://doi.org/10.1007/978-3-319-61615-5_11.

Kramm, J., Steinhoff, S., Werschmöller, S., Völker, B., & Völker, C. (2022). Explaining risk perception of microplastics: Results from a representative survey in Germany. *Global Environmental Change, 73*, 102485. https://doi.org/10.1016/j.gloenvcha.2022.102485.

Kwon, H.J., Hidayaturrahman, H., Peera, S.G., & Lee, T.G. (2022). Elimination of microplastics at different stages in Wastewater Treatment Plants. *Water*, *14*, 2404. https://doi.org/10.3390/w14152404.

Lam, C-S., Ramanathan, S., Carbery, M., Gray, K., Vanka, K. S., Maurin, C., Bush, R., & Palanisami, T. (2018). A comprehensive analysis of plastics and microplastic legislation worldwide. *Water, Air, and Soil Pollution, 229*, 345. https://doi.org/10.1007/s11270-018-4002-z.

Landon-Lane, M. (2018). Corporate social responsibility in marine plastic debris governance. *Marine Pollution Bulletin, 127*, 310-319. https://doi.org/10.1016/j.marpolbul.2017.11.054

Langseth, T., & Vyff, A. (2021). Cultural Dissonance: Surfers' Environmental Attitudes and Actions. *Frontiers in Sports and Active Living, 3*, 695048. https://doi.org/10.3389/fspor.2021.695048

Lara, O.H., Spalding, M.J., Navarrete, A.H., Park, C.A., & Braestrup, A. (2020). The Current State of Law on Plastic Pollution in Mexico and a View Toward the Future. In Stock, F., Reifferscheid, G., Brennholt, N., Kostianaia, E. (eds) *Plastics in the Aquatic Environment - Part II*. The Handbook of Environmental Chemistry, vol 112. Springer, Cham. https://doi.org/10.1007/698_2020_518

Laskar, N., & Kumar, U. (2019). Plastics and microplastics: A threat to environment. *Environmental Technology & Innovation*, *14*, 100352, https://doi.org/10.1016/j.eti.2019.100352.

Lasrado, F., & Zakaria, N. (2020). Go green! Exploring the organizational factors that influence self-initiated green behavior in the United Arab Emirates. *Asia Pacific Journal of Management*, *37*, 823-850. https://doi.org/10.1007/s10490-019-09665-1.

Latinopoulos, D., Mentis, C., & Bithas, K. (2018). The impact of a public information campaign on preferences for marine environmental protection. The case of plastic waste. *Marine Pollution Bulletin*, *131*(A), 151-162. https://doi.org/10.1016/j.marpolbul.2018.04.002

Lau, W.W.Y., Shiran, Y., Bailey, R.M., Cook, E., Stuchtey, M.R., Koskella, J., Velis, C.A., Godfrey, L., Boucher, J., Murphy, M.B., Thompson, R.C., Jankowska, E., Csstillo Castillo, A., Pilditch, T.D., Dixon, B., Koerselman, L., Kosior, E., Favoino, E., Gutberlet, J., Baulch, S., Atreya, M.E., Fischer, D., He, K.K., Petit, M.M., Sumaila, U.R., Neil. E., Bernhofen, M.V., Lawrence, K., and Palardy, J.E. (2020). Evaluating scenarios toward zero plastic pollution. *Science*, *369*, 1455-1461. https://doi.org/10.1126/science.aba9475

Law, K. L., & Thompson, R. C. (2014). Microplastics in the seas. *Science*, *345*(6193), 144-145. https://doi.org/10.1126/science.1254065

Law, K.L., Starr, N., Siegler, T.R., Jambeck, J.R., Mallos, N.J., & Leonard, G.H. (2020). The United States' contribution of plastic waste to land and ocean. *Science Advances*, *6*(44), eabd0288. https://doi.org/10.1126/sciadv.abd0288

Lebreton, L., van der Zwet, J., Damsteeg, J.W. et al. (2017). River plastic emissions to the world's oceans. *Nature Communications*, *8*, 15611. https://doi.org/10.1038/ncomms15611

Lee, Y-K., Kim, S., Kim, M-S., & Choi, J-G. (2014). Antecedents and interrelationships of three types of pro-environmental behaviour. *Journal of Business Research*, *67*(10), 2097-2105, https://doi.org/10.1016/j.jbusres.2014.04.018

Levine, M., & Ensom, M. H. (2001). Post hoc power analysis: an idea whose time has passed? *Pharmacotherapy*, *21*(4), 405-409. https://doi.org/10.1592/phco.21.5.405.34503

Lewin, W-C., M. S., Denfeld, G., & Strehlow, H. V. (2020). Recreational anglers' perceptions, attitudes, and estimated contribution to angling related marine litter in the German Baltic Sea. *Journal of Environmental Management*, *272*, 111062. https://doi.org/10.1016/j.jenvman.2020.111062

Li, C., Busquets, R, & Campos, L. C. (2020). Assessment of microplastics in freshwater systems: A review. *Science of The Total Environment*, *707*, 135578. https://doi.org/10.1016/j.scitotenv.2019.135578.

Li, W. C., Tse, H. F., & Fok, L. (2016). Plastic waste in the marine environment: A review of sources, occurrence, and effects. *Science of the Total Environment, 566–567*, 333-349. https://doi.org/10.1016/j.scitotenv.2016.05.084

Li, Z., Li, Q., Li, R., Zhao, Y., Geng, Ji., & Wang, G. (2020). Physiological responses of lettuce (*Lactuca sativa* L.) to microplastic pollution. *Environmental Science and Pollution Research*, *27*, 1-9. https://doi.org/10.1007/s11356-020-09349-0.

Lillis, T., & Curry, M. J. (2010). *Academic Writing in a Global Context: The politics and practices of publishing in English*. Abingdon: Routledge.

Lim, N. (2016). Cultural differences in emotion: differences in emotional arousal level between the East and the West. *Integrative Medicine Research*, *5*(2), 105-109. https://doi.org/10.1016/j.imr.2016.03.004.

Lin, Y.L., Wu, L.Y., Tsai, L.T., & Chang, C.C. (2020). The beginning of marine sustainability: preliminary results of measuring students' marine knowledge and ocean literacy. *Sustainability*, *12*(17), 7115. https://doi.org/10.3390/su12177115

Linder, N., Lindahl, T., & Borgström, S. (2018). Using behavioural insights to promote food waste recycling in urban households—Evidence from a longitudinal field experiment. *Frontiers in Psychology*, *9*, 352. https://doi.org/10.3389/fpsyg.2018.00352

Linklater, W. L., Farnworth, M. J., Heezik, Y., Stafford, K. J., & MacDonald, E.A. (2019). Prioritizing cat-owner behaviors for a campaign to reduce wildlife depredation. *Conservation Science and Practice, 1*(5), e29. https://doi.org/10.1111/csp2.29

Liu, T., Geng, L., Ye, L, & Zhou, K. (2019). "Mother Nature" enhances connectedness to nature and pro-environmental behaviour. *Journal of Environmental Psychology, 61*, 37-45, https://doi.org/10.1016/j.jenvp.2018.12.003.

Liu, Z., Wang, J., & Wang Y. (2018). Understanding individual environmental concern in the context of local environmental governance in China: A Multi-Level analysis. *Society and Natural Resources, 31*(11), 1283-1301. https://doi.org/10.1080/08941920.2018.1456595

Loganathan, Y., & Kizhakedathi, M. P. J. (2023). A review on microplastics - An indelible ubiquitous pollutant. *Biointerface Research in Applied Chemistry, 13*(2), 126. https://doi.org/10.33263/BRIAC132.126.

Löhr, A., Savelli, H., Beunen, R., Kalz, M., Ragas, A., & Van Belleghem, F. (2017). Solutions for global marine litter pollution. *Current Opinion in Environmental Sustainability, 28*, 90-99. http://dx.doi.org/10.1016/j.cosust.2017.08.009.

Long, X., Chen, Y., Du, J., Oh, K., Han, I., & Yan, J. (2017). The effect of environmental innovation behavior on economic and environmental performance of 182 Chinese firms. *Journal of Cleaner Production, 166*, 1274-1282. https://doi.org/10.1016/j.jclepro.2017.08.070.

Loy, L. S., & Reese, G. (2019). Hype and hope? Mind-body practice predicts pro-environmental engagement through global identity. *Journal of Environmental Psychology, 66*, 101340. https://doi.org/10.1016/j.jenvp.2019.101340

Luo, Y., Douglas, J., Pahl, S., & Zhao, J. (2022). Reducing plastic waste by visualizing marine consequences. *Environment and Behavior, 54*(4), 809-832. https://doi.org/10.1177/00139165221090154

MacKinnon, D.P., Lockwood, C.M., Hoffman, J.M., West, S.G., & Sheets, V. (2002). A comparison of methods to test mediation and other intervening effects. *Psychological Methods, 12*, 23-44.

Magalhães, S., Alves, L., Medronho, B., Romano, A., & Rasteiro, M.d.G. (2020). Microplastics in ecosystems: from current trends to bio-based removal strategies. *Molecules, 25*, 3954. https://doi.org/10.3390/molecules25173954

Mahlich, J., Dilokthornsakul, P., Sruamsiri, R., & Chaiyakunapruk, N. (2018). Cultural beliefs, utility values, and health technology assessment. *Cost Effectiveness and Resource Allocation, 16*, 1-8. https://doi.org/10.1186/s12962-018-0103-1.

Mainardes, E.W., Yeh, T., & Leal, A. (2017). Consumers' evaluations of the efficiency of actions to improve environmental quality: A comparative study between Brazil and China. *International Journal of Consumer Studies, 41*, 659-670. https://doi.org/10.1111/ijcs.12379.

Mallett, R. K. (2012). Eco-guilt motivates eco-friendly behaviour. *Ecopsychology, 4*, 223-231. https://doi.org/10.1089/eco.2012.0031

Marazzi, L., Loiselle, S., Anderson, L. G., Rocliffe, S., & Winton, D. J. (2020). Consumer-based actions to reduce plastic pollution in rivers: A multi-criteria decision analysis approach. *PLoS One, 15*(8), e0236410. https://doi.org/10.1371/journal.pone.0236410

Mariano, S., Tacconi, S., Fidaleo, M., Rossi, M., & Dini, L. (2021). Micro and nanoplastics identification: classic methods and innovative detection techniques. *Frontiers in Toxicology, 3*, 636640. https://doi.org/10.3389/ftox.2021.636640

Marine Litter Solutions (2019). *Global Declaration 2019*, accessed February 2021. https://www.marinelittersolutions.com/about-us/joint-declaration/

Martinho, G., Balaia, N., & Pires, A. (2017). The Portuguese plastic carrier bag tax: The effects on consumers' behavior. *Waste Management, 61*, 3-12. https://doi.org/10.1016/j.wasman.2017.01.023

Masiá, P., Ardura, A., & García-Vázquez, E. (2021). Virgin polystyrene microparticles exposure leads to changes in gills DNA and physical condition in the Mediterranean

mussel *Mytilus galloprovincialis*. *Animals, 11*(8), 2317. https://doi.org/10.3390/ani11082317.

Masiá, P., Sol, D., Ardura, A., Laca, Am., Borrell, Y. J., Dopico, E., Laca, Ad., Machado-Schiaffino, G., Diaz, M., & Garcia-Vazquez, E. (2020). Bioremediation as a promising strategy for microplastics removal in wastewater treatment plants. *Marine Pollution Bulletin 156*, 111252. https://doi.org/10.1016/j.marpolbul.2020.111252.

McCright, A. M., & Sundström, A. (2013). Examining Gender Differences in Environmental Concern in the Swedish General Public, 1990-2011. *International Journal of Sociology, 43*(4), 63-86. https://doi.org/10.2753/IJS0020-7659430402

McKinley, E., & Fletcher, S. (2010). Individual responsibility for the oceans? An evaluation of marine citizenship by UK marine practitioners. *Ocean and Coastal Management, 53*(7), 379-384. https://doi.org/10.1016/j.ocecoaman.2010.04.012

McKinley, E., & Fletcher, S. (2012). Improving marine environmental health through marine citizenship: A call for debate. *Marine Policy, 36*(3), 839-843. https://doi.org/10.1016/j.marpol.2011.11.001

Mi, L. Qiao, L., Xu, T., Gan, X., Yang, H., Zhao, J., Qiao, Y., & Hou, J. (2020). Promoting sustainable development: The impact of differences in cultural values on residents' pro-environmental behaviors. *Sustainable Development, 28*(6), 1539-1553. https://doi.org/10.1002/sd.2103.

Milfont, T. C., & Fischer, R. (2010). Testing measurement invariance across groups: applications in cross-cultural research. *International Journal of Psychology Research, 3*(1), 111-121. https://doi.org/10.21500/20112084.857

Mishra, A. K., Singh, J., & Mishra, P. P. (2021). Microplastics in polar regions: An early warning to the world's pristine ecosystem. *Science of the Total Environment, 784*, 147149, https://doi.org/10.1016/j.scitotenv.2021.147149.

Misund, A., Tiller, R., Canning-Clode, J., Freitas, M., Schmidt, J. O., & Javidpour, J. (2020). Can we shop ourselves to a clean sea? An experimental panel approach to assess the persuasiveness of private labels as a private governance approach to microplastic pollution. *Marine Pollution Bulletin, 153*, 110927. https://doi.org/10.1016/j.marpolbul.2020.110927.

Mitrano, D. M., & Wohlleben, W. (2020). Microplastic regulation should be more precise to incentivize both innovation and environmental safety. *Nature Communications, 11*(1), 1-12. https://doi.org/10.1038/s41467-020-19069-1.

Mocatta, G., & Hawley, E. (2020). The coronavirus crisis as tipping point: communicating the environment in a time of pandemic. *Media International Australia, 177*(1), 119-124. https://doi.org/10.1177/1329878X20950030.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). Preferred Reporting Items for Systematic reviews and Meta-Analyses: The PRISMA statement. *PLoS Medicine, 6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097.

Mohiuddin, M., Al Mamun, A., Ali Syed, F., Mehedi Masud, M., & Su, Z. (2018). Environmental knowledge, awareness, and business school students' intentions to purchase green vehicles in emerging countries. *Sustainability, 10*, 1534-1542.

Moon, J., Chadee, D., & Tikoo, S. (2008). Culture, product type, and price influences on consumer purchase intention to buy personalized products online. *Journal of Business Research, 61*(1), 31-39. https://doi.org/10.1016/j.jbusres.2006.05.012.

Munoz-Melendez, G., Delgado-Ramos, G.C., & Diaz-Chavez, R. (2021). Circular Economy in Mexico. In: Ghosh, S.K., Ghosh, S.K. (eds) *Circular Economy: Recent Trends in Global Perspective*. Springer, Singapore. https://doi.org/10.1007/978-981-16-0913-8_16

Muposhi, A., Mpinganjira, M., & Wait, M. (2022). Considerations, benefits, and unintended consequences of banning plastic shopping bags for environmental sustainability: A systematic literature review. *Waste Management Research, 40*(3), 248–261. https://doi.org/10.1177/0734242X211003965.

Nadeem, M., Bahadar, S., Gull, A.A., & Iqbal, U. (2020). Are women eco-friendly? Board gender diversity and environmental innovation. *Business Strategy and the Environment, 29*, 3146– 3161. https://doi.org/10.1002/bse.2563.

Nam, C., Dong, H., & Lee, Y-A. (2017). Factors influencing consumers' purchase intention of green sportswear. *Fashion and Textiles, 4,* 2. https://doi.org/10.1186/s40691-017-0091-3.

Nguyen, X. C., Cham Dao, D., Tinh Nguyen, T., Ba Tran, Q., Huyen Nguyen, T. T., Anh Tuan, T., Phuong Nguyen, K. L., Nguyen, V-T., Kumar Nadda, A., Thanh-Nho, N., Chung, W. J., Chang, S. W., & Duc Nguyen, D. D. (2022). Generation patterns and consumer behavior of single-use plastic towards plastic-free university campuses. *Chemosphere, 291*(3), 133059. https://doi.org/10.1016/j.chemosphere.2021.133059

Nielsen, T.D., Hasselbalch, J., Holmberg, K., & Stripple, J. (2020). Politics and the plastic crisis: A review throughout the plastic life cycle. *WIREs Energy and Environment, 9*, e360. https://doi.org/10.1002/wene.360

Nketiah, E., Song, H., Cai, X., Adjei, M., Obuobi, B., Adu-Gyamfi, G., Cudjoe, D. (2022). Predicting citizens' recycling intention: Incorporating natural bonding and place identity into the extended norm activation model. *Journal of Cleaner Production*, *377*, 134425. https://doi.org/10.1016/j.jclepro.2022.134425.

Nuojua, S., Pahl, S., & Thompson, R. (2022). Ocean connectedness and consumer responses to single-use packaging. *Journal of Environmental Psychology*, *81*, 101814, https://doi.org/10.1016/j.jenvp.2022.101814

O'Brien, J., & Thondhlana, G. (2019). Plastic bag use in South Africa: Perceptions, practices, and potential intervention strategies. *Waste Management*, *84*, 320-328. https://doi.org/10.1016/j.wasman.2018.11.051

OECD (2022). *Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options*, OECD Publishing, Paris, https://doi.org/10.1787/de747aef-en.

Ojinnaka, D., & Aw, M. M. (2020). Micro and nano plastics: A consumer perception study on the environment, food safety threat and control systems. *Biomedical Journal of Scientific & Technical Research, 32*(2), 23998-24012. https://doi.org/10.26717/BJSTR.2020.31.005064.

Onyena, A. P., Aniche, D. C., Ogbolu, B. O., Rakib, M. R. J., Uddin, J., & Walker, T. R. (2021). Governance strategies for mitigating microplastic pollution in the marine environment: a review. *Microplastics*, *1*(1), 15-46. https://doi.org/10.3390/microplastics1010003.

Owusu, V., Addo, E., & Sundberg, C. (2013). Do economic incentives affect attitudes to solid waste source separation? Evidence from Ghana. *Resources, Conservation and Recycling, 78*, 115-123. https://doi.org/10.1016/j.resconrec.2013.07.002

Pacheco, M. H. S., Kuriya, S. P., Capobiango, C. S. C., Colombo Pimentel, T., Gomes Cruz, A., Esmerino, E. A., and Freitas, M. Q. (2018). Exploration of gender differences in bottled mineral water consumption: A projective study of consumer's perception in Brazil. *Journal of Sensory Studies*, *33*(4), e12434. https://doi.org/10.1111/joss.12434

Pahl, S., & Wyles, K. J. (2017). The human dimension: how social and behavioural research methods can help address microplastics in the environment. *Analytical Methods, 9*, 1404. https://doi.org/10.1039/C6AY02647H.

Pahl, S., Wyles, K. J., & Thompson, R. C. (2017). Channelling passion for the ocean towards plastic pollution. *Nature Human Behaviour, 1*, 697–699. https://doi.org/10.1038/s41562-017-0204-4.

Parashar, N., & Hait, S. (2021). Plastics in the time of COVID-19 pandemic: Protector or polluter?. *Science of the Total Environment, 759*, 144274. https://doi.org/10.1016/j.scitotenv.2020.144274.

Park, S.B., Kim, J-W., Lee, Y.K., & Ok, C. (2020). Visualizing theme park visitors' emotions using social media analytics and geospatial analytics. *Tourism Management 80*, 104127. https://doi.org/10.1016/j.tourman.2020.104127.

Patrício Silva, A. L., Prata, J.C., Walker, T.R., Campos, D., Duarte, A.C., Soares, A.M.V.M., Barcelò, D., & Rocha-Santos, T. (2020). Rethinking and optimising plastic waste

management under COVID-19 pandemic: Policy solutions based on redesign and reduction of single-use plastics and personal protective equipment. *Science of the Total Environment, 742*, 140565. https://doi.org/10.1016/j.scitotenv.2020.140565

Patrício Silva, A. L., Prata, J. C., Walker, T. R., Duarte, A. C., Ouyang, W., Barcelò, D., & Rocha-Santos, T. (2021). Increased plastic pollution due to COVID-19 pandemic: Challenges and recommendations. *Chemical Engineering Journal, 405*, 126683. https://doi.org/10.1016/j.cej.2020.126683.

Pejman, N., Kallas, Z., Dalmau, A., & Velarde, A. (2019). Should animal welfare regulations be more restrictive? A case study in eight European Union countries. *Animals, 9*(4), 195. https://doi.org/10.3390/ani9040195

Penca, J. (2018). European Plastics Strategy: What promise for global marine litter? *Marine Policy, 97*, 197-201. https://doi.org/10.1016/j.marpol.2018.06.004.

Peng, J., Wang, J., & Cai, L. (2017). Current understanding of microplastics in the environment: occurrence, fate, risks, and what we should do. *International Environmental Assessment and Management, 13*(3), 476-482. https://doi.org/10.1002/ieam.1912.

Phelan, A., Ross, H., Setianto, N. A., Fielding, K., & Pradipta, L. (2020). Ocean plastic crisis-Mental models of plastic pollution from remote Indonesian coastal communities. *PloS One, 15*, e0236149. https://doi.org/10.1371/journal.pone.0236149

Pieroni, M. P. P., McAloone, T. C., & Pigosso, D. C. A. (2019). Business model innovation for circular economy and sustainability: A review of approaches. *Journal of Cleaner Production, 215*, 198-216. https://doi.org/10.1016/j.jclepro.2019.01.036

PlasticsEurope (2020). *Plastics – the Facts 2020. An analysis of European latest plastics production, demand and waste data.* Plastics Europe, Brussels.

Polit, D.F., Beck, C.T., & Owen, S.V. (2007). Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Research on Nursing Health, 30*, 459-467. https://doi.org/10.1002/nur.20199.

Poškus, M.S., & Žukauskienė, R. (2017). Predicting adolescents' recycling behavior among different big five personality types. *Journal of Environmental Psychology, 54*, 57-64. https://doi.org/10.1016/j.jenvp.2017.10.003.

Prata, J.C. (2018). Airborne microplastics: consequences to human health? *Environmental Pollution, 234*, 115-126.

Prata, J. C., Silva, A. L. P., da Costa, J. P., Mouneyrac, C., Walker, T. R., Duarte, A. C., & Rocha-Santos, T. (2019). Solutions and Integrated Strategies for the Control and Mitigation of Plastic and Microplastic Pollution. *International Journal of Environmental Research and Public Health, 16*, 2411. https://doi.org/10.3390/ijerph16132411.

Prata, J. C., da Costa, J. P., Lopes, I., Duarte, A. C., & Rocha-Santos, T. (2020). Environmental exposure to microplastics: An overview on possible human health effects. *Science of the Total Environment, 702*, 134455. https://doi.org/10.1016/j.scitotenv.2019.134455.

Prata, J. C., da Costa, J. P., Lopes, I., Andrady, A. L., Duarte, A. C., & Rocha-Santos, T. (2021). A One Health perspective of the impacts of microplastics on animal, human and environmental health. *Science of the Total Environment, 777*, 146094. https://doi.org/10.1016/j.scitotenv.2021.146094.

Qian, N. (2018). Bottled water or tap water? A comparative study of drinking water choices on university campuses. *Water, 10*(1), 59. https://doi.org/10.3390/w10010059

Raab, P., & Bogner, F. X. (2020). Microplastics in the environment: raising awareness in primary education. *The American Biology Teacher, 82*(7), 478-487. https://doi.org/10.1525/abt.2020.82.7.478.

Rahimi, A., & García, J. M. (2017). Chemical recycling of waste plastics for new materials production. *Nature Reviews Chemistry, 1*(6), 1-11. https://doi.org/10.1038/s41570-017-0046

Ramstetter, L., & Habersack, F. (2020). Do women make a difference? Analysing environmental attitudes and actions of Members of the European Parliament.

Environmental Politics, 29(6), 1063-1084. https://doi.org/10.1080/09644016.2019.1609156

Raubenheimer, K., & Urho, N. (2020). Rethinking global governance of plastics-The role of industry. *Marine Policy, 113*, 103802. https://doi.org/10.1016/j.marpol.2019.103802.

Rausch, T. M., & Kopplin, C. S. (2021). Bridge the gap: Consumers' purchase intention and behavior regarding sustainable clothing. *Journal of Cleaner Production, 278*, 123882 https://doi.org/10.1016/j.jclepro.2020.123882

Raykov, T., & Marcoulides, G. A. (2017). Thanks coefficient alpha, we still need you! *Educational Psychology Measurement, 79*(1), 200-210. https://doi.org/10.1177/0013164417725127.

Rayon-Viña, F., Miralles, L., Gomez-Agenjo, M., Dopico, E., & Garcia-Vazquez, E. (2018). Marine litter in south Bay of Biscay: Local differences in beach littering are associated with citizen perception and awareness. *Marine Pollution Bulletin, 131*, 727-735. https://doi.org/10.1016/j.marpolbul.2018.04.066

Rayon-Viña, F., Fernandez-Rodriguez, S., Ibabe, A., Dopico, E., & Garcia-Vazquez, E. (2022). Public awareness of beach litter and alien invasions: Implications for early detection and management. *Ocean and Coastal Management, 219*, 106040. https://doi.org/10.1016/j.ocecoaman.2022.106040.

Razzini, K., Castrica, M., Menchetti, L., et al. (2020). SARS-CoV-2 RNA detection in the air and on surfaces in the COVID-19 ward of a hospital in Milan, Italy. *Science of the Total Environment, 742*, 140540. https://doi.org/10.1016/j.scitotenv.2020.140540

Rech, S., Thiel, M., Borrell, Y. J., & Garcia-Vazquez, E. (2018). Travelling light: Fouling biota on macroplastics arriving on beaches of remote Rapa Nui (Easter Island) in the South Pacific Subtropical Gyre. *Marine Pollution Bulletin, 137*, 119-128. https://doi.org/10.1016/j.marpolbul.2018.10.015

Reed, M.R., & Chen, W.-T. (2022). Plastics Crash Course: A website for teaching plastics recycling and microplastics prevention through infographics. *Recycling, 7*, 65. https://doi.org/10.3390/recycling7050065

Rees, J.H., Klug, S., & Bamberg, S. (2015). Guilty conscience: motivating pro-environmental behavior by inducing negative moral emotions. *Climate Change, 130*, 439-452. https://doi.org/10.1007/s10584-014-1278-x

Reichert, F., & Torney-Purta, J. (2019). A cross-national comparison of teachers' beliefs about the aims of civic education in 12 countries: A person-centered analysis. *Teaching and Teacher Education, 77*, 112-125. https://doi.org/10.1016/j.tate.2018.09.005

Reike, D., Vermeulen, W.J.V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring controversies in the conceptualization of the Circular Economy through a focus on history and Resource Value Retention Options. *Resources, Conservation and Recycling, 135*, 246-264. https://doi.org/10.1016/j.resconrec.2017.08.027

Rhein, S., & Sträter, K. F. (2021). Corporate self-commitments to mitigate the global plastic crisis: Recycling rather than reduction and reuse. *Journal of Cleaner Production, 296*, 126571. https://doi.org/10.1016/j.jclepro.2021.126571.

Rist, S., Almroth, B. C., Hartmann, N. B., & Karlsson, T. M. (2018). A critical perspective on early communications concerning human health aspects of microplastics. *Science of The Total Environment, 626*, 720-726. https://doi.org/10.1016/j.scitotenv.2018.01.092.

Roblin, B., Ryan, M., Vreugdenhil, A., & Aherne, J. (2020). Ambient atmospheric deposition of anthropogenic microfibers and microplastics on the western periphery of Europe (Ireland). *Environmental Science and Technology, 54*, 11100-11108. https://dx.doi.org/10.1021/acs.est.0c04000.

Rochman, C.M., Kross, S.M., Armstrong, J.B., Bogan, M.T., Darling, E.S., Green, S.J., Smyth, A.R., & Veríssimo, D. (2015). Scientific evidence supports a ban on microbeads. *Environmental Science and Technology, 49*(18), 10759-10761. https://doi.org/10.1021/acs.est.5b03909.

Rochman, C.M., Brookson, C., Bikker, J., Djuric, N., Earn, A., Bucci, K., et al. (2019), Rethinking microplastics as a diverse contaminant suite. *Environmental Toxicology Chemistry*, 38, 703-711. https://doi.org/10.1002/etc.4371.

Rodrigues, M.O., Abrantes, N., Gonçalves, F.J.M., Nogueira, H., Marques, J. C., & Gonçalves, A.M.M. (2019). Impacts of plastic products used in daily life on the environment and human health: What is known? *Environmental Toxicology and Pharmacology, 72*, 103239. https://doi.org/10.1016/j.etap.2019.103239

Rosseto, M., Krein, D.D., Balbé, N.P., & Dettmer, A. (2019). Starch–gelatin film as an alternative to the use of plastics in agriculture: a review. *Journal of the Science of Food and Agriculture, 99*, 6671-6679. https://doi.org/10.1002/jsfa.9944

Royer, S. J., Ferrón, S., Wilson, S. T., & Karl, D. M. (2018). Production of methane and ethylene from plastic in the environment. *PloS One*, *13*(8), e0200574. https://doi.org/10.1371/journal.pone.0200574.

Rubio-Aparicio, M., Marín-Martínez, F., Sánchez-Meca, J., & López-López, J. A. (2018). A methodological review of meta-analyses of the effectiveness of clinical psychology treatments. *Behavior Research Methods, 50*, 2057-2073. https://doi.org/10.3758/s13428-017-0973-8.

Ruggero, F., Gori, R., & Lubello, C. (2020). Methodologies for microplastics recovery and identification in heterogeneous solid matrices: a review. *Journal of Polymers and the Environment*, *28*(3), 739-748. https://doi.org/10.1007/s10924-019-01644-3

de Ruijter, V. N., Redondo-Hasselerharm, P. E., Gouin, T., & Koelmans, A. A. (2020). Quality criteria for microplastic effect studies in the context of risk assessment: a critical review. *Environmental Science and Technology, 54*, 11692-11705. https://doi.org/10.1021/acs.est.0c03057

de Sá, L.C., Oliveira, M., Ribeiro, F., Rocha, T.L., & Futter, M.N. (2018). Studies of the effects of microplastics on aquatic organisms: what do we know and where should we focus our efforts in the future? *Science of the Total Environment, 645*, 1029-1039. https://doi.org/10.1016/j.scitotenv.2018.07.207

SAM (2018). *Microplastic Pollution: the Policy Context - Background Paper*. The Scientific Advice Mechanism Unit of the European Commission, p. 68 web version https://ec.europa.eu/research/sam/pdf/topics/microplastic_pollution_policy-context.pdf accessed February 2021.

SAPEA, Science Advice for Policy by European Academies. (2019). *A Scientific Perspective on Microplastics in Nature and Society*. SAPEA, Berlin. https://doi.org/10.26356/microplastics.

Schäfer, M. S. (2008). Mediatization of Science? Empirical assessment of a sociological concept. *Zeitschrift für Soziologie*, *37*(3), 206-225. https://doi.org/10.1515/zfsoz-2008-0302.

Schnurr, R. E. J., Alboiu, V., Chaudhary, M., Corbett, R. A., Quanz, M. E., Sankar, K., Srain, H. S., Thavarajah, V., Xanthos, D., & Walker, T. R. (2018). Reducing marine pollution from single-use plastics (SUPs): A review. *Marine Pollution Bulletin, 137*, 157-171. https://doi.org/10.1016/j.marpolbul.2018.10.001.

Schönbauer, S., & Müller, R. (2021). A Risky Object? How microplastics are represented in the German media. *Science Communication*, *43*(5), 543-569. https://doi.org/10.1177/10755470211030519.

Schultz, P. W. (2011). Conservation means behavior. *Conservation Biology*, *25*(6), 1080-1083. https://doi.org/10.1111/j.1523-1739.2011.01766.x.

Schulz, W., Ainley, J., Fraillon, J., Losito, B., Agrusti, G., & Friedman, T. (2018). *Becoming citizens in a changing world*. IEA International Civic and Citizenship Education Study 2016 international report (p. 243). Springer Nature.

Sfriso, A. A., Tomio, Y., Rosso, B., Gambaro, A., Sfriso, A., Corami, F., Rastelli, E., Corinaldesi, C., Mistri, M., & Munari, C. (2020). Microplastic accumulation in benthic invertebrates in Terra Nova Bay (Ross Sea, Antarctica). *Environment International*, *137*, 105587. https://doi.org/10.1016/j.envint.2020.105587.

Sharma, S., Sharma, V., & Chatterjee, S. (2023). Contribution of plastic and microplastic to global climate change and their conjoining impacts on the environment - A review. *Science of The Total Environment*, *875*, 162627. https://doi.org/10.1016/j.scitotenv.2023.162627.

Shen, J., & Saijo, T. (2008). Reexamining the relations between socio-demographic characteristics and individual environmental concern: Evidence from Shanghai data. *Journal of Environmental Psychology*, *28*(1), 42-50. https://doi.org/10.1016/j.jenvp.2007.10.003.

Shen, M., Huang, W., Chen, M., Song, B., Zeng, G., & Zhang, Y. (2020). (Micro)plastic crisis: Un-ignorable contribution to global greenhouse gas emissions and climate change. *Journal of Cleaner Production*, *254*, 120138. https://doi.org/10.1016/j.jclepro.2020.120138.

Shen, M., Zeng, Z., Song, B., Yi, H., Hu, T., Zhang, Y., ... & Xiao, R. (2021). Neglected microplastics pollution in global COVID-19: Disposable surgical masks. *Science of the Total Environment*, *790*, 148130. https://doi.org/10.1016/j.scitotenv.2021.148130.

Short, E. R., Cox, D. T. C., Tan, Y. L., Bethel, A., Eales, J. F., & Garside, R. (2021). Review of the evidence for oceans and human health relationships in Europe: A systematic map. *Environment International*, *146*, 106275, https://doi.org/10.1016/j.envint.2020.106275.

Shruti, V. C., Pérez-Guevara, F., Elizalde-Martínez, I., & Kutralam-Muniasamy, G. (2020). Reusable masks for COVID-19: a missing piece of the microplastic problem during the global health crisis. *Marine Pollution Bulletin*, *161*, 111777. https://doi.org/10.1016%2Fj.marpolbul.2020.111777.

Siles, J., Prebble, M., Wen, J., Hart, C., & Schuttenberg, H. (2019). *Advancing Gender in the Environment: Gender in Fisheries - A Sea of Opportunities*. IUCN and USAID. Washington, USA: USAID. Available at: https://genderandenvironment.org/advancing-gender-in-the-environment-gender-in-fisheries-a-sea-of-opportunities/

Singh, S., Trushna, T., Kalyanasundaram, M., Tamhankar, A. J., & Diwan, V. (2022). Microplastics in drinking water: a macro issue. *Water Supply*, *22*(5), 5650-5674. https://doi.org/10.2166/ws.2022.189

Slavin, C., Grage, A., & Campbell, M. L. (2012). Linking social drivers of marine debris with actual marine debris on beaches. *Marine Pollution Bulletin*, *64*(8), 1580-1588. https://doi.org/10.1016/j.marpolbul.2012.05.018.

Smith, M., Love, D.C., Rochman, C.M., & Neff, R. A. (2018). Microplastics in seafood and the implications for human health. *Current Environmental Health Reports*, *5*, 375-386. https://doi.org/10.1007/s40572-018-0206-z.

Soares, J., Miguel, I., Venâncio, C., Lopes, I., & Oliveira, M. (2020). Perspectives on micro(nano)plastics in the marine environment: biological and societal considerations. *Water*, *12*, 3208. https://doi.org/10.3390/w12113208

Soares, J., Miguel, I., Venâncio, C., Lopes, I., & Oliveira, M. (2021). Public views on plastic pollution: Knowledge, perceived impacts, and pro-environmental behaviours. *Journal of Hazardous Materials*, *412*, 125227. https://doi.org/10.1016/j.jhazmat.2021.125227.

Soutter, A. R. B., & Boag, S. (2019). Environmental advertising: the effect of imagery on pro-environmental attitudes and pro-environmental behaviour / Publicidad medioambiental: el efecto de las imágenes sobre las actitudes proambientales y el comportamiento proambiental. *PsyEcology*, *10*(1), 88-126. https://doi.org/10.1080/21711976.2018.1550238

Sreen, N., Purbey, S., & Sadarangani, P. (2018). Impact of culture, behavior, and gender on green purchase intention. *Journal of Retailing and Consumer Services*, *41*, 177-189. https://doi.org/10.1016/j.jretconser.2017.12.002.

Steenkamp, J-B. E. M., & Baumgartner, H. (1998). Assessing Measurement Invariance in cross-national consumer research. *Journal of Consumption Research*, *25*(1), 78-107. https://doi.org/10.1086/209528.

Steg, L., Bolderdijk, J. W., Keizer, K. & Perlaviciute, G. (2014). An integrated framework for encouraging pro-environmental behaviour: the role of values, situational factors, and goals. *Journal of Environmental Psychology, 38*, 104-115. https://doi.org/10.1016/j.jenvp.2014.01.002

Steinmetz, H. (2018). *Estimation and comparison of latent means across cultures*. In: Cross-Cultural Analysis: Methods and Applications, eds. E. Davidov, P. Schmidt, J. Billiet, and B. Meuleman, 2nd edition. Routledge Taylor & Francis Group.

Stern, P. C. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues, 56*, 407-424.

Stoett, P., & Omrow, D. A. (2021). The transnationalization of hazardous waste. In: *Spheres of Transnational Ecoviolence*, pp. 73-101, Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-58561-7_3.

Sujata, M., Khor, K-S., Ramayah, T., & Teoh, A. P. (2019). The role of social media on recycling behavior. *Sustainable Production and Consumption, 20*, 365–374. https://doi.org/10.1016/j.spc.2019.08.005.

Sun, S., Pan, W., & Wang, L. L. (2010). A comprehensive review of effect size reporting and interpreting practices in academic journals in education and psychology. *Journal of Educational Psychology, 102*(4), 989-1004. https://doi.org/10.1037/a0019507

Sun, Y., Wang, S., Li, J., Zhao, D., & Fan, J. (2017). Understanding consumers' intention to use plastic bags: using an extended theory of planned behaviour model. *Nature Hazards, 89*, 1327-1342. https://doi.org/10.1007/s11069-017-3022-0

Swami, V., Chamorro-Premuzic, T., Snelgar, R., & Furnham, A. (2011). Personality, individual differences, and demographic antecedents of self-reported household waste management behaviours. *Journal of Environmental Psychology, 31*(1), 21-26, https://doi.org/10.1016/j.jenvp.2010.08.001.

Tagorti, G., & Kaya, B. (2022). Genotoxic effect of microplastics and COVID-19: The hidden threat. *Chemosphere, 286*, 131898, https://doi.org/10.1016/j.chemosphere.2021.131898.

Tessnow-von Wysocki, I., & Le Billon, P. (2019). Plastics at sea: Treaty design for a global solution to marine plastic pollution. *Environmental Science & Policy, 100*, 94-104. https://doi.org/10.1016/j.envsci.2019.06.005

Tian, H., & Liu, X. (2022). Pro-environmental behavior research: theoretical progress and future directions. *International Journal of Environmental Research and Public Health, 19*(11), 6721. https://doi.org/10.3390/ijerph19116721

Tian, W., Song, P., Zhang, H., Duan, X., Wei, Y., Wang, H., & Wang, S. (2023). Microplastic materials in the environment: Problem and strategical solutions. *Progress in Materials Science, 132*, 101035, https://doi.org/10.1016/j.pmatsci.2022.101035.

Tiller, R., Arenas, F., Galdies, C., Leitão, F., Malej, A., Romera, B. M., Solidoro, C., Stojanov, R., Turk, V., & Guerra, R. (2019). Who cares about ocean acidification in the Plasticene? *Ocean and Coastal Management, 174*, 170-180. https://doi.org/10.1016/j.ocecoaman.2019.03.020.

Tiller, R., & Nyman, E. (2018). Ocean plastics and the BBNJ treaty—is plastic frightening enough to insert itself into the BBNJ treaty, or do we need to wait for a treaty of its own? *Journal of Environmental Studies and Sciences, 8*(4), 411-415. https://doi.org/10.1007/s13412-018-0495-4.

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A.W.G., McGonigle, D., & Russell, A. E. (2004). Lost at sea: where is all the plastic? *Science, 304*, 838-838. https://doi.org/10.1126/science.1094559

Tonglet, M., Phillips, P. S., & Read, A. D. (2004). Using the theory of planned behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK. *Resources, Conservation and Recycling, 41*(3), 191–214. https://doi.org/10.1016/j.resconrec.2003.11.001

Tsiotsou, R. (2006). The role of perceived product quality and overall satisfaction on purchase intentions. *International Journal of Consumer Studies*, *30*(2), 207–217. https://doi.org/10.1111/j.1470-6431.2005.00477.x

Tuu, H. H., Olsen, S. O., & Khoi, N. H. (2022). The conflicting effects of self-construal on impulsive buying tendency toward unhealthy food: the moderating role of future time perspective. *Current Psychology*, 1-15. https://doi.org/10.1007/s12144-022-04054-2.

UN (2017). *UN declares war on ocean plastic*. UN Environment, United Nations News Centre. http://web.unep.org/newscentre/un-declares-war-ocean-plastic.

UN (2021). *Sustainable Development Goals*. United Nations Department of Economic and Social Affairs, https://sdgs.un.org/goals

UNDP (United Nations Development Programme). 2022. *Human Development Report 2021-22: Uncertain Times, Unsettled Lives: Shaping our Future in a Transforming World*. New York.

UNESCO-IOC (2021). The United Nations Decade of Ocean Science for Sustainable Development (2021-2030) Implementation plan – Summary. Paris, UNESCO. (IOC Ocean Decade Series, 19). Accessed 1 August 2022. https://www.oceandecade.org/wp-content/uploads/2021/09/337521-Ocean%20Decade%20Implementation%20Plan:%20Summary

United Nations (2015). *Transforming our World: The 2030 Agenda for Sustainable Development*. A/RES/70/1, available at https://sdgs.un.org/publications/transforming-our-world-2030-agenda-sustainable-development-17981 (accessed on April 2022).

United Nations (2018). *Decision BC-14/13: Further actions to address plastic waste under the Basel Convention*, United Nations Environment Programme Secretariat of the Basel Convention, UN 2018.

Usman, S., Razis, A. F. A., Shaari, K., Amal, M. N. A., Saad, M. Z., Isa, N. M., Nazarudin, M. F., Zulkifli, S. Z., Sutra, J., & Ibrahim, M. A. (2020). Microplastics pollution as an invisible potential threat to food safety and security, policy challenges and the way forward. *International Journal of Environmental Research and Public Health, 17*, 9591. https://doi.org/10.3390/ijerph17249591

Valerio, M.A., Rodriguez, N., Winkler, P., Lopez, J., Dennison, M., Liang, Y., & Turner, B. J. (2016). Comparing two sampling methods to engage hard-to-reach communities in research priority setting. *BMC Medical Research Methodology,16*, 146. https://doi.org/10.1186/s12874-016-0242-z

Van der Marel, E. R. (2022). Trading plastic waste in a global economy: soundly regulated by the Basel Convention? *Journal of Environmental Law*, *34*(3), 477-497. https://doi.org/10.1093/jel/eqac017.

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*, 523–538. https://doi.org/10.1007/s11192-009-0146-3.

Van Eck, N.J., & Waltman, L. (2011). Text mining and visualization using VOSviewer. *ISSI Newsletter, 7*(3), 50-54.

Van Wezel, A., Caris, I., & Kools, S.A.E. (2016). Release of primary microplastics from consumer products to wastewater in the Netherlands. *Environmental Toxicology and Chemistry, 35*, 1627-1631. https://doi.org/10.1002/etc.3316

Van Wijnen, J., Ragas, A. M. J., & Kroeze, C. (2019). Modelling global river export of microplastics to the marine environment: Sources and future trends. *Science of the Total Environment, 673, 392-401*. https://doi.org/10.1016/j.scitotenv.2019.04.078

Vassanadumrongdee, S., Hoontrakool, D., & Marks, D. (2020). Perception and behavioral changes of Thai youths towards the plastic bag charging program. *Applied Environmental Research, 42*(2), 27–45. https://doi.org/10.35762/AER.2020.42.2.3.

Velis, C. A. (2015). Circular economy and global secondary material supply chains. *Waste Management & Research, 33*, 389-391. http://dx.doi.org/10.1177/0734242X15587641

Velis, C. (2018). No circular economy if current systemic failures are not addressed. *Waste Management & Research, 36*(9), 757-759. https://doi.org/10.1177/0734242X18799579.

Vethaak, A. D., & Legler, J. (2021). Microplastics and human health. *Science, 371*(6530), 672-674. https://doi.org/10.1126/science.abe5041.

Vicente-Molina, M.A. Fernández-Sainz, A., & Izagirre-Olaizola, J. (2018). Does gender make a difference in pro-environmental behavior? The case of the Basque Country University students. *Journal of Cleaner Production, 176*, 89-98. https://doi.org/10.1016/j.jclepro.2017.12.079.

Vidal, E., Medail, F., & Tatoni, T. (1998). Is the yellow-legged gull a superabundant bird species in the Mediterranean? Impact on fauna and flora, conservation measures and research priorities. *Biodiversity Conservation, 7*(8), 1013-1026, DOI 10.1023/A:1008805030578

Villarrubia-Gómez, P., Cornell, S. E., & Fabres, J. (2018). Marine plastic pollution as a planetary boundary threat – The drifting piece in the sustainability puzzle. *Marine Policy, 96*, 213-220. https://doi.org/10.1016/j.marpol.2017.11.035

Vimal, K.E.K., Mathiyazhagan, K., Agarwal, V., Luthra, S., & Sivakumar, K. (2020). Analysis of barriers that impede the elimination of single-use plastic in developing economy context. *Journal of Cleaner Production, 272*, 122629, https://doi.org/10.1016/j.jclepro.2020.122629.

Vince, J., & Hardesty, B. D. (2018). Governance solutions to the tragedy of the commons that marine plastics have become. *Frontiers in Marine Science, 5*, 214. https://doi.org/10.3389/fmars.2018.00214.

Vivekanand, A. C., Mohapatra, S., & Tyagi, V. K. (2021). Microplastics in aquatic environment: Challenges and perspectives. *Chemosphere, 282*, 131151, https://doi.org/10.1016/j.chemosphere.2021.131151.

Volker, C., Kramm, J., & Wagner, M. (2020). On the creation of risk: framing of microplastics risks in science and media. *Global Challenges, 4*, 1900010. https://doi.org/10.1002/gch2.201900010.

Wagner, M., & Lambert, S., eds. (2017). *Freshwater Microplastics - Emerging Environmental Contaminants?* The Handbook of Environmental Chemistry, 18. Springer Open, Cham, Switzerland. https://doi.org/10.1007/978-3-319-61615-5.

Wahinya, M. K. P., & Mironga, J. M. (2020). Effectiveness of the Implementation of Plastic Bags Ban: Empirical Evidence from Kenya. *African Journal of Environmental Science and Technology*, https://doi.org/10.9790/2402-1406025361

Walker, T.R., McGuinty, E., Charlebois, S., & Music, J. (2021). Single-use plastic packaging in the Canadian food industry: consumer behavior and perceptions. *Humanities and Social Sciences Communication, 8*, 80. https://doi.org/10.1057/s41599-021-00747-4

Wang, E. S-T., & Chu, Y-H. (2020). Influence of consumer's long-term orientation and safety consciousness on intention to repurchase certified functional foods. *Journal of Food Products Marketing, 26*(4), 247-261. https://doi.org/10.1080/10454446.2020.1757554.

Wang, X., & Lin, L. (2018). How climate change risk perceptions are related to moral judgment and guilt in China. *Climate Risk Management, 20*, 155-164. https://doi.org/10.1016/j.crm.2018.02.005

Wang, H., Shen, M., Song, Y., & Phau, I. (2020). Do up-displayed eco-friendly products always perform better? The moderating role of psychological distance. *Journal of Business Research, 114*, 198-212. https://doi.org/10.1016/j.jbusres.2020.03.031.

Wayman, C., & Niemann, H. (2021). The fate of plastic in the ocean environment – a minireview. *Environmental Sciences and Processes Impact, 23*, 198-212. https://doi.org/10.1039/D0EM00446D

Wee, S-C., Choong, W-W., & Low, S-T. (2021). Can "Nudging" Play a Role to Promote Pro-Environmental Behaviour? *Environmental Challenges, 5*, 100364. https://doi.org/10.1016/j.envc.2021.100364

Welzel, C., Brunkert, L., Kruse, S., & Inglehart, R. F. (2021). Non-invariance? An overstated problem with misconceived causes. *Sociological Methodology Research, 1*(33), 0049124121995521. doi:10.1177/0049124121995521.

Whitburn, J., Linklater, W., & Abrahamse, W. (2020). Meta-analysis of human connection to nature and proenvironmental behavior. *Conservation Biology, 34*, 180-193. https://doi.org/10.1111/cobi.13381.

Whitley, C. T., Kalof, L., & Flach, T. (2021). Using animal portraiture to activate emotional affect. *Environment and Behavior*, *53*(8), 837–863. https://doi.org/10.1177/0013916520928429

Wiefek, J., Steinhorst, J., & Beyerl, K. (2021). Personal and structural factors that influence individual plastic packaging consumption—Results from focus group discussions with German consumers. *Cleaner and Responsible Consumption, 3*, 2021, 100022, https://doi.org/10.1016/j.clrc.2021.100022.

Wieland, S., Balmes, A., Bender, J., Kitzinger, J., Meyer, F., Ramsperger, A. F. R. M., Roeder, F., Tengelmann, C., Wimmer, B. H., Laforsch, C., & Kress, H. (2022). From properties to toxicity: Comparing microplastics to other airborne microparticles. *Journal of Hazardous Materials, 428*, 128151, https://doi.org/10.1016/j.jhazmat.2021.128151.

Wolstenholme, E., Poortinga W., & Whitmarsh, L. (2020) Two birds, one stone: The effectiveness of health and environmental messages to reduce meat consumption and encourage pro-environmental behavioral spillover. *Frontiers in Psychology*, *11*, 577111. https://doi.org/10.3389/fpsyg.2020.577111

Woodall, L. C., Sanchez-Vidal, A., Canals, M., Paterson, G. L. J., Coppock, R., Sleight, V., Calafat, A., Rogers, A. D., Narayanaswamy, B. E., & Thompson, R. C. (2014). The deep sea is a major sink for microplastic debris. *Royal Society Open Science, 1*, 140317. http://dx.doi.org/10.1098/rsos.140317.

Worm, B., Elliff, C., Fonseca, J. G., Gell, F.R., Serra-Gonçalves, C., Helder, N.K., Murray, K., Peckham, H., Prelovec, L., & Sink, K. (2021). Making ocean literacy inclusive and accessible. *Ethics in Science and Environmental Pollution, 21*, 1-9. doi:10.3354/esep00196.

Wu, S. J., & Paluck, E. L. (2021). Designing nudges for the context: golden coin decals nudge workplace behavior in China. *Organizational Behavior and Human Decision Processes*, *163*, 43-50. https://doi.org/10.1016/j.obhdp.2018.10.002.

Wuensch, K.L. (2012). Screening data. Retrieved from http://core.ecu.edu/psyc/wuenschk/MV/Screening/Screen.docx in April 2022.

Xanthos, D., & Walker, T.R. (2017). International policies to reduce plastic marine pollution from single-use plastics (plastic bags and microbeads): A review. *Marine Pollution Bulletin*, *118*, 17-26, https://doi.org/10.1016/j.marpolbul.2017.02.048

Xiao, C., & McCright, A. M. (2015). Gender differences in environmental concern: Revisiting the institutional trust hypothesis in the USA. *Environment and Behavior*, *47*(1), 17-37. https://doi.org/10.1177/0013916513491571

Xiao, Y., Liu, X., & Ren, T. (2022). Internet use and pro-environmental behavior: Evidence from China. *PLoS One*, *17*(1), e0262644. https://doi.org/10.1371/journal.pone.0262644

Xie, X., Huo, J., & Zou, H. (2019). Green process innovation, green product innovation, and corporate financial performance: A content analysis method. *Journal of Business Research*, *101*, 697-706. https://doi.org/10.1016/j.jbusres.2019.01.010.

Xu, B., Liu, F., Cryder, Z., Huang, D., Lu, Z., He, Y., Wang, H., Lu, Z., Brookes, P. C., Tang, C., Gan, J., & Xu, J. (2020). Microplastics in the soil environment: Occurrence, risks, interactions and fate – A review. *Critical Reviews in Environmental Science and Technology*, *50*(21), 2175-2222. https://doi.org/10.1080/10643389.2019.1694822

Yadav, S.S., Kar, S.K., & Rai, P.K. (2022). Why do consumers buy recycled shoes? An amalgamation of the theory of reasoned action and the theory of planned behaviour. *Frontiers in Environmental Science*, *10*, 1007959. https://doi.org/10.3389/fenvs.2022.1007959

Yan, Z., & Cortese, J. (2023). I can feel your pain: investigating the role of empathy and guilt on sustainable behavioral intentions to Reduce, Reuse, and Recycle plastic bags among college students. *Sustainability*, *15*, 6572. https://doi.org/10.3390/su15086572.

Yan, S., Henninger, C. E., Jones, C., & McCormick, H. (2020). Sustainable knowledge from consumer perspective addressing microfibre pollution. *Journal of Fashion Marketing and Management*, *24*(3), 437-454. https://doi.org/10.1108/JFMM-08-2019-0181.

Yoon, A., Jeong, D., & Chon, J. (2021). The impact of the perceived risk and conservation commitment of marine microplastics on tourists' pro-environmental behaviors. *Science of the Total Environment*, *774*, 144782. https://doi.org/10.1016/j.scitotenv.2020.144782

Yuan, Z., Nag, R., & Cummins, E. (2022). Human health concerns regarding microplastics in the aquatic environment - From marine to food systems. *Science of The Total Environment*, *823*, 153730. https://doi.org/10.1016/j.scitotenv.2022.153730

Yurtsever, M. (2019). Glitters as a source of primary microplastics: an approach to environmental responsibility and ethics. *Journal of Agricultural and Environmental Ethics*, *32*, 459-478. https://doi.org/10.1007/s10806-019-09785-0.

Zhang, X., Gong, X., & Jiang, J. (2021). Dump or recycle? Nostalgia and consumer recycling behavior. *Journal of Business Research*, *132*, 594-603. https://doi.org/10.1016/j.jbusres.2020.11.033.

Zhang, Y., Kang, S., Allen, S., Allen, D., Gao, T., & Sillanpää, M. (2020a). Atmospheric microplastics: A review on current status and perspectives. *Earth-Science Reviews*, *203*, 103118. https://doi.org/10.1016/j.earscirev.2020.103118.

Zhang, Y., Pu, S., Lv, X., Gao, Y., & Ge, L. (2020b). Global trends and prospects in microplastics research: A bibliometric analysis. *Journal of Hazardous Materials*, *400*, 123110. https://doi.org/10.1016/j.jhazmat.2020.123110.

Zwicker, M. V., Nohlen, H. U., Dalege, J., Gruter, G-J. M., & van Harreveld, F. (2020). Applying an attitude network approach to consumer behaviour towards plastic. *Journal of Environmental Psychology*, *69*, 101433. https://doi.org/10.1016/j.jenvp.2020.101433

ANNEX I

SUPPLEMENTARY TABLES

Supplementary table 3.1. List of review and perspective papers about psychosocial issues of microplastics pollution that have been fully evaluated in this study (box purple in Figure 1). Cited by author/s (year) and DOI.

Dauvergne, P. (2018). https://doi.org/10.1016/j.gloenvcha.2018.05.002.

Katsnelson, A. (2015). https://doi.org/10.1073/pnas.1504135112.

Kramm, J., & Volker, C. (2018). DOI 10.1007/978-3-319-61615-5_11.

Lam, C-S., Ramanathan, S., Carbery, M., Gray, K., Vanka, K. S., Maurin, C., Bush, R., & Palanisami, T. (2018). https://doi.org/10.1007/s11270-018-4002-z.

Landon-Lane, M. (2018). https://doi.org/10.1016/j.marpolbul.2017.11.054.

Lohr, A., Savelli, H., Beunen, R., Kalz, M., Ragas, A., & Van Belleghem, F. (2017). https://doi.org/10.1016/j.cosust.2017.08.009.

Mitrano, D. M., & Wohlleben, W. (2020). https://doi.org/10.1038/s41467-020-19069-1.

Pahl, S., & Wyles, K. J. (2017). DOI: 10.1039/C6AY02647H.

Penca, J. (2018). https://doi.org/10.1016/j.marpol.2018.06.004.

Prata, J. C., Patrício Silva, A. L., da Costa, J. P., Mouneyrac, C., Walker, T. R., Duarte, A.C., & Rocha-Santos, T. (2019). https://doi.org/10.3390/ijerph16132411.

SAPEA (2019). https://doi.org/10.26356/microplastics.

Schnurr, R. E. J., Alboiu,V., Chaudhary, M., Corbett, R. A., Quanz, M. E., Sankar, K., Srain, H. S., Thavarajah, V., Xanthos, D., & Walker, T. R. (2018). https://doi.org/10.1016/j.marpolbul.2018.10.001.

Soares, J., Miguel, I., Venâncio, C., Lopes, I., & Oliveira, M. (2020). https://doi.org/10.3390/w12113208.

Usman, S., Razis, A. F. A., Shaari, K., Amal, M. N. A., Saad, M. Z., Isa, N. M., Nazarudin, M. F., Zulkifli, S. Z., Sutra, J., & Ibrahim, M. A. (2020). https://doi.org/10.3390/ijerph17249591.

Volker, C., Kramm, J., & Wagner, M. (2020). DOI: 10.1002/gch2.201900010.

Yurtsever, M. (2019). https://doi.org/10.1007/s10806-019-09785-0.

Supplementary table 4.1. Journals analyzed in this study, by country.

Country	Journal name	Website
Canada	The Globe and Mail	https://www.theglobeandmail.com/
	The National Post	https://nationalpost.com/
	Toronto Star	https://www.thestar.com/
Mexico	El Universal	https://www.eluniversal.com.mx/
	Excélsior	https://www.excelsior.com.mx/
	Milenio	https://www.milenio.com/
Spain	El Mundo	https://www.elmundo.es/
	La Vanguardia	https://www.lavanguardia.com/
	20 Minutos	https://www.20minutos.es/

Supplementary table 4.2. List of relevant terms (in English and Spanish) and its frequency in the news about microplastics retained for analysis after quality filtering, from newspapers of Canada (total word count in the retained news *n* = 38125), Mexico (*n* = 60561) and Spain (*n* = 132822).

	Spanish	English	Canada	Mexico	Spain
Actor	Autoridad	Authority	3	21	11
Actor	Capital	Capital	5	18	8
Actor	Científico/Académico	Scientist/Academic expert	112	123	175
Actor	Ciudadano	Citizen	9	18	79
Actor	Consumidor	Consumer	16	12	32
Actor	Economía	Economy	25	29	50
Actor	Empresa/compañía	Company/Corporation/Enterprise	20	39	83
Actor	Equipo	Team	18	39	89
Actor	Gobierno	Government	68	41	46
Actor	Industria	Industry	29	87	77
Actor	Ministerio	Ministry	0	3	20
Actor	Ropa/moda	Fashion/Clothe	35	24	97
Actor	Trabajo	Work	46	20	86
Actor	Universidad	University	26	82	162
Environment	Animal	Animal	41	82	109
Environment	Ballena	Whale	37	56	12
Environment	Clima	Climate	49	42	17
Environment	Ecosistema	Ecosystem	16	37	105
Environment	Especie	Species	13	102	160
Environment	Medioambiente	Environment	175	96	188
Environment	Naturaleza	Nature	11	21	72
Environment	Pingüino/pájaro	Penguin/bird	7	28	23

Environment	Tortuga	Turtle	7	40	51
Environment	Africa	Africa	2	5	6
Environment	Agua	Water	211	203	374
Environment	Aire	Air	30	24	73
Environment	América	America	11	11	24
Environment	Antártico	Antarctic	1	39	55
Environment	Ártico	Arctic	75	49	58
Environment	Asia	Asia	4	6	14
Environment	Ciudad	City	26	51	32
Environment	Costa	Coast	41	28	118
Environment	Europa	Europe	12	39	158
Environment	Fondo marino	Ocean bottom	7	5	16
Environment	Lago/laguna	Lake/pond	79	7	26
Environment	Océano/Mar/Medio marino	Ocean/Marine	151	175	308
Environment	Pandemia	Pandemic	26	16	48
Environment	Playa	Beach	45	49	196
Environment	Río	River	36	29	68
Environment	Tierra	Earth/Planet	35	32	54
Food	Pesca	Fishing/Fisheries	20	47	3
Food	Cultivo	Cultivation, crop	0	14	14
Food	Leche	Milk	1	8	7
Food	Agricultura	Agriculture	1	1	13
Food	Alimento	Food	51	61	93
Food	Pescado/marisco	Seafood	1	43	57
Food	Peces	Fish	73	53	73
Health	Estómago	Stomach	7	19	29
Health	Heces/Excrementos	Feces/fecal/scat/poop	11	18	47
Health	Placenta	Placenta	5	8	14
Health	COVID/coronavirus/virus	COVID/coronavirus/virus	26	26	28
Health	Higiene	Hygiene	1	6	9
Health	Pulmón	Lung	14	16	21
Health	Salud	Health	55	117	189
Health	Sangre	Blood	11	23	31
Pollutant	Basura marina	Marine debris/garbage	71	4	21
Pollutant	Bolsa	Bag	115	87	95
Pollutant	Botella	Bottle	75	51	128
Pollutant	Contaminación	Pollution	112	237	295
Pollutant	Contenedor	Container	34	14	25
Pollutant	Cosméticos	Cosmetics	3	8	40
Pollutant	Envase	Packaging	45	65	127
Pollutant	Ingrediente	Ingredient	3	9	11
Pollutant	Mascarilla	Mask	17	17	55
Pollutant	Microfibras	Microfibres	19	13	23
Pollutant	Micropartícula	Microparticle	1	5	12
Pollutant	Microplástico	Microplastic	202	340	814
Pollutant	Milímetro	Millimeter	10	17	37

Pollutant	Nanoplásticos	Nanoplastics	1	9	40
Pollutant	Pajita/popote	Straw	46	46	21
Pollutant	Envoltorio/Envase	Plastic packaging	66	779	148
Pollutant	Polietileno, PET	Polyethylene, PET	2	79	47
Pollutant	Redes de pesca	Fishing net	1	21	44
Pollutant	Tamaño	Size	14	33	82
Pollutant	Uso de plástico	Plastic use	11	13	11
Solution	Acción	Action	18	30	70
Solution	Alternativa	Alternative	18	11	36
Solution	Consumo/consumir	Consumption/consume	9	55	111
Solution	Debate/controversia/discusión	Debate/controversy	3	2	11
Solution	Declaración	Statement/Report	72	28	21
Solution	Legislación	Legislation	9	5	17
Solution	Ley	Law	29	48	40
Solution	Limpieza/limpiar	Cleaning	74	22	87
Solution	Medida	Measure	17	42	83
Solution	Mitigar	Mitigation	3	0	8
Solution	Política	Politics	7	16	37
Solution	Prohibición	Ban	161	28	56
Solution	Reciclar	Recycle	79	94	180
Solution	Reducción/Reducir	Reduce	53	71	163
Solution	Reutilizar	Reuse	6	27	76
Solution	Sostenibilidad/sostenible	Sustainability/sustainable	41	24	90
Solution	Tratamiento de aguas/aguas residuales	Wastewater treatment/wastewater plant	11	7	11
Solution	Informe	Report	66	26	56
Understanding	Alerta	Alert/Alarm	5	16	38
Understanding	Amenaza	Threat	22	26	74
Understanding	Evaluar/evaluación	Assessment	28	15	43
Understanding	Extinción/extinto	Extinction	1	20	16
Understanding	Riesgo	Risk	18	30	65
Understanding	Conocer/conocimiento	Knowledge	49	46	88
Understanding	Conciencia	Awareness	10	27	86

Supplementary table 4.3. Terms with >0.3 relevance selected using VOSviewer software (Van Eck & Waltman, 2010) in the considered newspapers. Term categories are: A, actors; G, goods from which E is environment, F is food and H is health; P, pollutants; S, solutions; U, understanding.

		Canada	Mexico	Spain
A	Academic expert	0.42		
A	Citizen			1.69
A	Government	0.75		
A	Person		0.31	
A	Scientist			0.84
A	Team			0.71
A	Volunteer			0.32
A	Woman	1.51		
G-E	Air			0.51
G-E	Antarctica		1.08	1
G-E	Bay	1.12		
G-E	Beach		2.12	
G-E	Environment	1.22	0.46	0.67
G-E	Lake	1.76		
G-E	Natural space			1.65
G-E	Nature			1.17
G-E	Ocean		1.03	
G-E	Penguin		1.21	
G-E	River	1.51		1.61
G-E	Sea	1.49		
G-E	Species		0.6	1.03
G-E	Water		0.52	
G-E	Whale		1.11	
G-E	World			0.82
G-F	Anchovy			1.05
G-F	Food		1.11	
G-F	Product		0.59	
G-H	Covid	1.16		
G-H	Feces			1.48
G-H	Human health		1.24	1.84
G-H	Life			1.67
G-H	Lung	3.33		
G-H	Stomach			0.56
P	Bag		0.73	
P	Contamination		1.03	
P	Cup	0.97		
P	Garbage	0.93	1.95	
P	Grey water	1		
P	Laundry room	1.16		
P	Packaging		1.09	

P	Piece			0.51
P	Plastic bag	0.82		
P	Plastic particle	1.25	1.45	
P	Plastic pollution	0.66		1.09
P	Plastic waste	0.68	2.01	
P	Residue			2.33
P	Straw	0.62	1.34	
P	SUP	0.58	0.96	
S	Ban	0.61		
S	Law	1.34		
S	Report	0.6		0.51
U	Alert		2.66	
U	Awareness			0.23
U	Concern	0.87		

Supplementary table 5.1. Questionnaire scoring

Block A
A1: as Male = 0; Female = 1; Non binary = 2.
A2: from 1 = 18-30 to 5 = >60
A3: from the number of formal education years, as Junior high school or lower = 1; Senior high school = 2; Vocational college / Undergraduate = 3; Graduate or above = 4.
A4: from 1 = <500$ to 6 = >5000$
A5: the answer to this question was fit into the best-matching field of the UNESCO International Standard Classification of Education (ISCED, 2011), available at http://uis.unesco.org/sites/default/files/documents/international-standard-classification-of-education-isced-2011-en.pdf, accessed on April 2022.
A6: beach frequentation. The score was inverted against the options displayed, from 1 = Never to 6 = Every day
Block B
B1 and B2 were scored according to the R imperative of Reducing, from 1 = Every time to 5 = Never.
B3 was scored according to the R imperative of Recycling, from 1 = Never to 5 = Every time.
B4 was not scored. The answers were analyzed as alternative values in a qualitative variable. "Dispose as general trash" represents no R behaviour, "Dispose in the recycling bin" represents Recycling, "Reuse" is a direct R, "Use for other purposes" is Repurpose and "I never use this type of goods" is Refuse.
B5 and B6 were scored as 1 = reason marked or 0 = reason not marked.
Block C
The participants scored directly the four questions, from the least (= 1) to the most (= 7) feeling of responsibility or sustainable behavior intention.

Supplementary table 5.2. Summary of the comparison among groups and post-hoc tests conducted on the variables related with marine citizenship and single use plastics (SUP) reduction. ANOVA F-value or tie-corrected Hc of Kruskal-Wallis tests (when conditions for ANOVA are not met) are presented, with their *p* values. The significance of paired post-hoc tests is given as *, **, * and n.s. for $p < 0.05$, $p < 0.01$, $p < 0.001$ and not significant, respectively. MS, Mexican students; SS, Spanish students; SNS, Spanish non-students.**

			Post-hoc tests		
Variable	**Test value**	***p* value**	**MS-SS**	**MS-SNS**	**SS-SNS**
Sea frequentation	Hc = 225	1.41×10^{-49}	***	***	n.s.
Responsibility for the ocean	$F_{(2,929)} = 5.44$	0.005	n.s.	*	**
Intention to reduce SUP	Hc = 6.87	0.02	n.s.	**	n.s.
Intention to buy eco-friendly products	Hc = 21.77	1.87×10^{-5}	**	***	**
Reduced bag consumption	Hc = 176	5.97×10^{-39}	**	***	***
Reduced bottle consumption	Hc = 44.42	2.26×10^{-10}	***	***	**

Supplementary table 5.3. Pairwise correlations between the considered elements of marine citizenship, sea frequentation and responsibility for the sea, and the pro-environmental behavior variables analyzed. Pearson's r and its significance is given. Significance as *, **, * and n.s. for $p < 0.05$, $p < 0.01$, $p < 0.001$ and not significant, respectively. Bonferroni correction was applied.**

	Intended SUP reduction	Reduce bags	Reduce bottles	Intended eco-friendly purchase	Intended recycling	Recycling
Mexican students						
Sea frequentation	-0.07 n.s.	0.01 n.s.	-0.09 n.s.	-0.09 n.s.	-0.10 n.s.	-0.05 n.s.
Responsibility for the sea	0.58 ***	-0.03 n.s.	-0.04 n.s.	0.56 ***	0.55 ***	-0.08 n.s.
Spanish students						
Sea frequentation	0.09 n.s.	0.05 n.s.	0.04 n.s.	0.07 n.s.	0.13 n.s.	0.17 *
Responsibility for the sea	0.49 ***	0.11 n.s.	0.06 n.s.	0.36 ***	0.32 ***	-0.09 n.s.
Spanish non students						
Sea frequentation	0.02 n.s.	0.01 n.s.	-0.08 n.s.	0.03 n.s.	0.03 n.s.	0.15 **
Responsibility for the sea	0.52 ***	0.06 n.s.	0.02 n.s.	0.52 ***	0.44 ***	0.03 n.s.

Supplementary table 5.4. Multivariate multiple regression analysis of the Spanish non-students sample. Significant results are highlighted in bold. SE, standard error.

Tests on independent variables						
	Wilks lambda	***F***	**df1**	**df2**	***p***	
Education	0.9791	1.2	6	336	0.308	
Age	**0.945**	**3.26**	**6**	**336**	**0.004**	
Sea frequentation	0.972	1.63	6	336	0.1377	
Gender	0.971	1.68	6	336	0.1242	
Feeling of responsibility	**0.677**	**26.76**	**6**	**336**	**4.89×10^{-23}**	
Tests on dependent variables						
	R^2	$F(5, 341)$	df1	df2	*p*	
Reduced SUP bags	0.026	1.81	5	341	0.1108	
Reduced SUP bottles	0.018	1.26	5	341	0.2828	
Recycling	**0.077**	**5.72**	**5**	**341**	**0.04**	
Intention to reduce SUP	**0.292**	**28.12**	**5**	**341**	**7.4×10^{-21}**	
Intention to recycle	**0.217**	**18.92**	**5**	**341**	**1.32×10^{-13}**	
Intention to buy eco-friendly	**0.285**	**27.11**	**5**	**341**	**4.31×10^{-20}**	
Regression coefficients and statistics						
		Coeff.	SE	*t*	*p*	R^2
Reduced SUP bags	Constant	2.67	0.31	8.69	<<0.001	
	Education	0.11	0.07	1.64	0.10	0.009
	Age	0.05	0.04	1.33	0.19	0.001

	Sea frequentation	-0.01	0.05	0.23	0.82	0.0002
	Gender	0.2	0.11	1.87	0.06	0.01
	Feeling of responsibility	0.03	0.03	1.31	0.19	0.004
Reduced SUP bottles	Constant	2.61	0.42	6.21	<<0.001	
	Education	0.06	0.09	0.65	0.52	0.0005
	Age	0.08	0.05	1.44	0.15	0.003
	Sea frequentation	-0.11	0.07	1.68	0.09	0.006
	Gender	0.21	0.15	1.48	0.14	0.005
	Feeling of responsibility	0.02	0.04	0.51	0.61	0.0002
Recycling	Constant	2.24	0.37	6.08	<<0.001	
	Education	**0.19**	**0.08**	**2.42**	**0.016**	**0.02**
	Age	0.19	0.05	3.96	0.91	0.04
	Sea frequentation	**0.12**	**0.06**	**2.16**	**0.03**	**0.02**
	Gender	0.09	0.13	0.67	0.50	0.001
	Feeling of responsibility	0.04	0.03	1.16	0.25	0.001
Intention to reduce SUP	Constant	2.07	0.5	4.15	0.42	
	Education	0.05	0.11	0.47	0.64	0.004
	Age	**0.16**	**0.06**	**2.48**	**0.01**	**0.0003**
	Sea frequentation	0.01	0.08	0.12	0.90	0.0004
	Gender	**0.44**	**0.17**	**2.52**	**0.01**	**0.01**
	Feeling of responsibility	**0.5**	**0.04**	**11.53**	**<<0.001**	**0.27**
Intention to recycle	Constant	2.51	0.54	4.68	0.04	
	Education	0.13	0.11	1.17	0.24	0.008
	Age	**0.19**	**0.07**	**2.71**	**0.007**	**0.0004**
	Sea frequentation	0.02	0.08	0.20	0.84	0.0008
	Gender	0.22	0.19	1.17	0.24	0.003
	Feeling of responsibility	**0.44**	**0.05**	**9.47**	**<<0.001**	**0.19**
Intention to buy eco-friendly	Constant	1.76	0.53	3.35	0.001	
	Education	0.07	0.11	0.64	0.52	0.006
	Age	0.1	0.07	1.45	0.15	0.004
	Sea frequentation	0.03	0.08	0.34	0.74	0.001
	Gender	**0.45**	**0.18**	**2.46**	**0.01**	**0.014**
	Feeling of responsibility	**0.51**	**0.05**	**11.21**	**<<0.001**	**0.27**

Supplementary table 5.5. Multivariate multiple regression analysis of the Mexican students sample. Significant results are highlighted in bold. β, coefficient; SE, standard error.

Tests on independent variables						
	Wilks lambda	*F*	df1	df2	*p*	
Sea frequentation	0.9749	1.41	6	328	0.2102	
Gender	**0.943**	**3.3**	**6**	**328**	**0.004**	
Feeling of responsibility	**0.631**	**31.97**	**6**	**328**	**$3.06x10^{-27}$**	
Tests on dependent variables						
	R^2	*F*	df1	df2	*p*	
Plastic bags	0.006	0.62	3	333	0.603	
Plastic bottles	**0.044**	**5.079**	**3**	**333**	**0.002**	
Recycling	0.013	1.47	3	333	0.222	
Intention to reduce SUP	**0.351**	**60.08**	**3**	**333**	**$4.53x10^{-28}$**	
Intention to recycle	**0.319**	**51.97**	**3**	**333**	**$1.41x10^{-24}$**	
I will buy eco-friendly	**0.332**	**55.17**	**3**	**333**	**$5.67x10^{-26}$**	
Regression coefficients and statistics						
		β	SE	*t*	*p*	R^2
Plastic bags	Constant	28.188	0.234	12.034	$6.14x10^{-24}$	
	Sea frequentation	0.015	0.079	0.186	0.853	0.0002
	Gender	-0.131	0.110	-11.877	0.236	0.005
	Feeling of responsibility	-0.013	0.025	-0.510	0.610	0.001
Plastic bottles	Constant	3.67	0.211	17.423	$8.87x10^{-45}$	
	Sea frequentation	-0.11	0.071	-15.385	0.125	0.008
	Gender	**0.34**	**0.099**	**34.263**	**0.0007**	**0.034**
	Feeling of responsibility	-0.025	0.022	-1.114	0.266	0.002
Recycling	Constant	37.571	0.313	12.019	$6.96x10^{-24}$	
	Sea frequentation	-0.165	0.106	-15.625	0.119	0.007
	Gender	-0.022	0.147	-0.152	0.879	0.0001
	Feeling of responsibility	-0.048	0.033	-14.402	0.151	0.006
Intention to reduce SUP	Constant	31.649	0.378	83.788	$1.52x10^{-11}$	
	Sea frequentation	-0.221	0.128	-17.268	0.085	0.010
	Gender	**0.441**	**0.178**	**2.483**	**0.014**	**0.027**
	Feeling of responsibility	**0.510**	**0.040**	**12.729**	**$1.63x10^{-26}$**	**0.333**
Intention to recycle	Constant	35.568	0.379	93.768	$1.08x10-^{14}$	
	Sea frequentation	**-0.28**	**0.128**	**2.19**	**0.029**	**0.015**
	Gender	0.195	0.179	10.912	0.276	0.011
	Feeling of responsibility	**0.483**	**0.04**	**12.009**	**$7.53x10^{-24}$**	**0.306**
Intention to buy eco-friendly	Constant	3.283	0.373	87.968	$7.73x10^{-13}$	
	Sea frequentation	-0.177	0.126	-14.029	0.162	0.008
	Gender	**0.360**	**0.176**	**20.499**	**0.041**	**0.021**
	Feeling of responsibility	**0.488**	**0.04**	**12.327**	**$5.1x10^{-25}$**	**0.319**

Supplementary table 5.6. Multivariate multiple regression analysis of the Spanish students sample. Significant results are highlighted in bold. β, coefficient; SE, standard error.

Tests on independent variables					
	Wilks lambda	***F***	**df1**	**df2**	***p***
Sea frequentation	0.972	1.133	6	239	0.344
Gender	0.954	1.91	6	239	0.08
Feeling of responsibility	**0.772**	**11.78**	**6**	**239**	**1.43** x10^{-08}
Tests on dependent variables					
	R^2	*F*	df1	df2	*p*
Plastic bags	0.024	1.964	3	244	0.12
Plastic bottles	0.007	0.541	3	244	0.655
Recycle	0.031	2.639	3	244	0.05
Intention to reduce SUP	**0.285**	**32.42**	**3**	**244**	**1.13 x10^{-17}**
Intention to recycle	**0.121**	**11.16**	**3**	**244**	**6.86 x10^{-04}**
Intention to buy eco-friendly	**0.152**	**14.6**	**3**	**244**	**8.91 x10^{-06}**
Regression coefficients and statistics						
		β	**SE**	***t***	***p***	**R^2**
Plastic bags	Constant	1.997	0.204	97.451	3.65x10^{-15}	
	Sea frequentation	0.041	0.041	0.987	0.324	0.004
	Gender	0.131	0.119	11.044	0.271	0.013
	Feeling of responsibility	0.039	0.028	14.159	0.158	0.013
Plastic bottles	Constant	28.121	0.317	88.783	1.50x10^{-12}	
	Sea frequentation	0.040	0.064	0.633	0.527	0.002
	Gender	0.098	0.183	0.532	0.595	0.003
	Feeling of responsibility	0.031	0.043	0.722	0.471	0.003
Recycling	Constant	36.923	0.345	10.704	3.59x10^{-18}	
	Sea frequentation	**0.156**	**0.07**	**2.249**	**0.025**	0.025
	Gender	0.111	0.199	0.555	0.579	0.001
	Feeling of responsibility	-0.061	0.047	-12.855	0.199	0.008
Intention to reduce SUP	Constant	27.795	0.35766	77.714	2.16x10^{-09}	
	Sea frequentation	0.117	0.072	16.211	0.106	0.004
	Gender	**0.646**	**0.207**	**31.217**	**0.002**	**0.115**
	Feeling of responsibility	**0.373**	**0.049**	**76.096**	**5.98x10^{-10}**	0.243
Intention to recycle	Constant	40.534	0.387	10.486	1,77x10^{-17}	
	Sea frequentation	0.146	0.078	18.703	0.063	0.008
	Gender	0.236	0.224	10.561	0.292	0.034
	Feeling of responsibility	**0.253**	**0.053**	**47.719**	**0.03**	0.101
Intention to buy eco-friendly	Constant	30.949	0.418	7.397	2.23x10^{-08}	
	Sea frequentation	0.12	0.084	14.264	0.155	0.004
	Gender	0.448	0.242	1.85	0.066	0.056
	Feeling of responsibility	**0.299**	**0.057**	**52.201**	**3.83x10^{-03}**	0.129

Supplementary table 5.7. Pairwise correlations between the variables analyzed in the whole study sample. Significant results after Bonferroni correction are highlighted in bold.

	Gender	Responsibility for the ocean	Sea frequentation	Intended SUP reduction	Intended eco-friendly purchase	Intended recycling	Recycling	SUP bag consumption	SUP bottle consumption
Gender		**0.0002**	0.289	**3.39×10^{-09}**	**4.02×10^{-07}**	**0.001**	0.97	0.496	**5.91×10^{-04}**
Responsibility for the ocean	**0.124**		0.088	**5.80×10^{-70}**	**7.15×10^{-60}**	**2.54×10^{-48}**	0.06	0.712	0.474
Sea frequentation	0.035	-0.056		0.596	0.201	0.217	**2.36×10^{-10}**	0.023	**5.86×10^{-05}**
Intended SUP reduction	**0.193**	**0.536**	-0.017		**1.97×10^{-255}**	**6.18×10^{-184}**	**0.0005**	**8.22×10^{-04}**	**1.73×10^{-05}**
Intended eco-friendly purchase	**0.166**	**0.501**	-0.042	**0.847**		**6.21×10^{-158}**	0.005	0.054	**1.98×10^{-07}**
Intended recycling	**0.106**	**0.454**	0.041	**0.772**	**0.735**		**1.59×10^{-28}**	**0.002**	0.017
Recycling	0.001	-0.061	**0.207**	**0.114**	0.091	**0.353**		**1.79×10^{-06}**	0.827
SUP bag consumption	-0.022	-0.012	0.075	**0.11**	0.063	0.1	**0.156**		**2.68×10^{-04}**
SUP bottle consumption	**0.113**	0.024	**-0.132**	**0.141**	**0.17**	0.078	-0.007	**0.12**	

Supplementary table 5.8. Regression analysis of the dependent variable *reduce SUP bag consumption*; expected mediators *intention to reduce SUP* (mediation #1) and *intention to buy eco-friendly* (mediation #2)); and the independent variable *gender*. Unstandardized regression coefficients (B), their standard error (SE), t statistics and its p-value, and R^2 of the partial correlation. For each mediation zero order regression predicting the constant from the mediator are presented first, then multiple regression results of the three variables.

Mediation #1 $Z_\alpha * Z_\beta = 16.01$	**B**	**SE**	***t***	***p***	**R^2**
Constant (intention to reduce SUP)	4.91	0.101	48.83	$5.2x10^{-258}$	
Gender	0.745	0.125	5.97	$3.38x10^{-9}$	0.04
Constant (reduce SUP bottles)	2.61	0.124	20.96	$4.32x10^{-80}$	
Intention to reduce SUP	0.08	0.021	3.74	$1.99x10^{-4}$	0.02
Gender	0.223	0.083	2.69	$7.35x10^{-3}$	0.013
Mediation #2 $Z_\alpha * Z_\beta = 10.76$					
Constant (intention to buy eco-friendly)	2.91	0.206	14.14	$3.32x10^{-41}$	
Gender	0.423	0.113	3.71	$2.1x^{10-4}$	0.03
Constant (reduce SUP bottles)	3.09	0.167	18.51	$3.08x^{10-65}$	
Intention to buy eco-friendly	0.129	0.039	3.29	0.001	0.028
Gender	0.23	0.08	2.81	0.005	0.013

Supplementary table 5.9. Multivariate multiple regression analysis in the whole sample, with both intended and actual pro-environmental behaviors (A) and only actual behaviors (B) as dependent variables. Significant results are highlighted in bold. β, coefficient; SE, standard error.

A)

Tests on independent variables					
	Wilks lambda	***F***	**df1**	**df2**	***p***
Sea frequentation	0.989	1.662	6	915	0.127
Country	0.873	22.29	6	915	0.000
Gender	0.962	6.111	6	915	0.000
Feeling responsible	0.684	70.33	6	915	0.000
Tests on dependent variables					
	R^2	***F***	**df1**	**df2**	***p***
Reduce SUP bags	0.019	4.529	4	920	0.001
Reduce SUP bottles	0.061	14.96	4	920	0.000
Recycling	0.100	25.68	4	920	0.000
Intended SUP reduction	0.304	100.5	4	920	0.000
Intended eco-friendly purchase	0.270	85.08	4	920	0.000
Intention to recycle	0.220	64.96	4	920	0.000
Regression coefficients and statistics					
		β	**SE**	***t***	***p***	**R^2**
Reduce SUP bags	Constant	2.976	0.144	20.677	0.000	
	Sea frequentation	0.017	0.033	0.509	0.611	0.006

	Country	**-0.271**	**0.077**	**-3.503**	**0.000**	**0.019**
	Gender	-0.043	0.070	-0.612	0.541	0.001
	Feeling responsible	-0.002	0.016	-0.120	0.904	0.000
Reduce SUP bottles	Constant	2.980	0.165	18.029	0.000	
	Sea frequentation	-0.053	0.038	-1.390	0.165	0.017
	Country	**0.482**	**0.089**	**5.420**	**0.000**	**0.047**
	Gender	**0.278**	**0.081**	**3.438**	**0.001**	**0.013**
	Feeling responsible	0.000	0.019	0.000	1.000	0.001
Recycling	Constant	3.776	0.181	20.843	0.000	
	Sea frequentation	**0.103**	**0.041**	**2.490**	**0.013**	**0.043**
	Country	**-0.733**	**0.097**	**-7.523**	**0.000**	**0.092**
	Gender	0.025	0.089	0.277	0.781	0.000
	Feeling responsible	-0.031	0.021	-1.506	0.132	0.004
Intended SUP reduction	Constant	2.725	0.219	12.426	0.000	
	Sea frequentation	0.027	0.050	0.530	0.596	0,000
	Country	0.078	0.118	0.657	0.511	0,001
	Gender	**0.492**	**0.107**	**4.587**	**0.000**	**0.037**
	Feeling responsible	**0.467**	**0.025**	**18.745**	**0.000**	**0.287**
Intended eco-friendly purchase	Constant	2.560	0.232	11.053	0.000	
	Sea frequentation	0.044	0.053	0.826	0.409	0.002
	Country	**0.396**	**0.125**	**3.180**	**0,002**	**0.012**
	Gender	**0.409**	**0.113**	**3.612**	**0.000**	**0.027**
	Feeling responsible	**0.449**	**0.026**	**17.083**	**0.000**	**0.251**
Intention to recycle	Constant	3.601	0.232	15.543	0.000	
	Sea frequentation	0.036	0.053	0.688	0.492	0.002
	Country	**-0.361**	**0.125**	**-2.896**	**0.004**	**0.008**
	Gender	0.197	0.113	1.739	0.082	0.011
	Feeling responsible	**0.405**	**0.026**	**15.403**	**0.000**	**0.206**

B)

Tests on independent variables

	Wilks Lambda	***F***	**df1**	**df2**	***p***
Intended SUP reduction	0.979	6.712	3	915	0.000
Intended eco-friendly purchasing	0.988	3.693	3	915	0.012
Intention to recycle	0.831	61.95	3	915	0.000
Sea frequentation	0.990	3.056	3	915	0.028
Country	0.927	24.07	3	915	0.000
Gender	0.989	3.494	3	915	0.015
Feeling responsible	0.959	13.02	3	915	0.000

Tests on dependent variables

	R^2	***F***	**df1**	**df2**	***p***
Reduce SUP bags	0.041	5.606	7	917	2E-06
Reduce SUP bottles	0.085	12.12	7	917	7E-15
Recycling	0.279	50.69	7	917	4E-61

Regression coefficients and statistics

		β	**SE**	***t***	***p***	**R^2**

Reduce SUP bags	Constant	2.709	0.160	16.883	0.000	
	Intended SUP reduction	0.115	0.038	3.016	0.003	0.012
	Intended eco-friendly purchase	-0.031	0.034	-0.899	0.369	0.004
	Intention to recycle	0.009	0.030	0.312	0.755	0.010
	Sea frequentation	0.015	0.033	0.451	0.652	0.006
	Country	-0.264	0.079	-3.346	0.001	0.019
	Gender	-0.089	0.071	-1.253	0.210	0.001
	Feeling responsible	-0.045	0.019	-2.366	0.018	0.000
Reduce SUP bottles	Constant	2.700	0.184	14.672	0.000	
	Intended SUP reduction	0.041	0.044	0.941	0.347	0.020
	Intended eco-friendly purchase	**0.094**	**0.039**	**2.371**	**0.018**	**0.029**
	Intention to recycle	-0.020	0.034	-0.577	0.564	0.006
	Sea frequentation	-0.057	0.037	-1.524	0.128	0.017
	Country	**0.434**	**0.091**	**4.794**	**0.000**	**0.047**
	Gender	**0.223**	**0.081**	**2.755**	**0.006**	**0.013**
	Feeling responsible	**-0.053**	**0.022**	**-2.420**	**0.016**	**0.001**
Recycling	Constant	2.657	0.183	14.526	0.000	
	Intended SUP reduction	**-0.127**	**0.043**	**-2.942**	**0.003**	**0.03**
	Intended eco-friendly purchase	**-0.077**	**0.039**	**-1.967**	**0.050**	**0.008**
	Intention to recycle	**0.462**	**0.034**	**13.558**	**0.000**	**0.125**
	Sea frequentation	**0.093**	**0.037**	**2.504**	**0.012**	**0.043**
	Country	**-0.526**	**0.090**	**-5.839**	**0.000**	**0.092**
	Gender	0.028	0.081	0.344	0.731	0.000
	Feeling responsible	**-0.124**	**0.022**	**-5.685**	**0.000**	**0.004**

Supplementary Table 6.1. Questionnaire analyzed in this study including question codes and scoring.

A.1 Gender 0 Male 1 Female 2 Non binary/Other		
A.2 Age: 1 18-30 2 30-40 3 40-50 4 50-60 5 Above 60		
A.3 Education level: 1 Junior high school or lower 2 Senior high school 3 Vocational college 4 undergraduate 5 Graduate or above		
A.4 Country (open question)		
B.1 How often do you check the microbeads content in the labels of cleansers and personal care products? 5 Every time 4 Usually 3 Sometimes 2 Seldom 1 Never		
B.2 Please choose the reason for not checking microbeads on product labels (multiple choice)		
	B.2.1 No time to read labels while shopping	
	B.2.2 No check labels of this type of products	
	B.2.3 I do not know/I do not care about microbeads	
	B.2.4 Lettering on labels is too small	
	B.2.5 I do not know how to recognize microbeads in the labels	
	B.2.6 I do check labels regularly	
	B.2.7 I do not trust labels	
	B.2.8 Other	
C.1 Have you heard about microplastics before this survey? Yes = 1 No = 0 Not sure = blank		
C.3 Which of the following items do you think are the sources of microplastics? (multiple choice)		
	C.3.1 Tyres	
	C.3.2 Synthetic textiles	
	C.3.3 Road markings	
	C.3.4 Ship paint	
	C.3.5 Factory production of plastic particles	
	C.3.6 Toiletries	
	C.3.7 Glitter	
	C.3.8 Plastic trash	
	C.3.9 Other	
C.4 Where do you think microplastics are finally accumulating in the environment? (multiple choice)		
	C.4.1 Rivers and lakes	
	C.4.2 Soil	
	C.4.3 Air	
	C.4.4 Animals and plants	
	C.4.5 Ocean	
	C.4.6 Beaches	
	C.4.7 Human bodies	
	C.4.8 Other	
C.5 In which ways do you think microplastics might enter a human body? (multiple choice)		
	C.5.1 Water	
	C.5.2 Honey	
	C.5.3 Salt	
	C.5.4 Seafood	

	C.5.5 Breathing air
	C.5.6 Body scrub
	C.5.7 Cosmetics
	C.5.8 Other
C.6 What policies do you think the government should enact to reduce microplastic pollution?	
	C.6.1 Offer free reusable bags
	C.6.2 Award reusing plastic bags
	C.6.3 Increase taxes of plastic products
	C.6.4 Stop selling products with microplastics
	C.6.5 Education
	C.6.6 Strict plastic usage law
	C.6.7 Improve water purification technology
	C.6.8 Other
D Could you please rate the following statements? (between 1 = extremely unlikely / I totally disagree and 7= extremely likely / I totally agree)	
	D.1- Microplastics can cause serious problems in our society.
	D.2- Microplastics entering the body can be a serious danger to health.
	D.3- Microplastics destroy the marine ecosystem.
	D.4- I will reduce my consumption of everyday items containing microplastics.
	D.5- I will buy or use eco-friendly products whenever possible.

Supplementary Table 7.1. Raw data of this study. Responses to the questionnaire are presented by sample type (students S or non-students NoS) and, in students, by experimental group (A, B, C and Control=Co).

Sample	Treatment	Formation	Gender	Age group	Personal responsibility	Microbead check	Reduce plastics	Refuse MP	Buy ecofriendly	Sort litter	Pro-environmental action
S	A	4	1	5	4	4	7	7	7	7	7
S	A	5	1	4	4	1	4	4	6	7	4
S	A	2	1	1	5	4	7	7	7	7	7
S	A	2	1	1	7	1	7	7	7	7	7
S	A	3	1	1	6	1	3	3	3	3	3
S	A	2	1	1	5	1	6	6	6	7	5
S	A	2	1	1	5	1	7	7	7	7	7
S	A	2	1	1	4	1	6	6	6	7	6
S	A	2	1	1	3	1	3	3	3	3	3
S	A	2	1	1	5	1	4	6	6	6	4
S	A	2	1	1	4	1	6	6	3	7	3
S	A	2	1	1	7	1	7	7	7	7	7
S	A	2	1	4	7	3	6	6	6	6	6
S	A	2	1	1	6	1	5	5	4	7	5
S	A	2	1	1	4	1	7	6	6	7	6
S	A	2	1	1	2	1	7	7	7	7	7
S	A	2	1	1	6	1	7	7	7	7	7
S	A	2	1	1	5	1	6	6	7	7	5
S	A	5	1	1	2	1	2	2	2	2	2
S	A	2	1	1	2	1	7	7	4	7	4
S	A	2	1	1	2	1	3	3	3	3	2
S	A	2	1	1	4	1	6	6	5	7	5
S	A	2	1	1	1	1	5	6	5	7	7
S	A	2	1	1	5	1	7	7	7	7	6
S	A	2	1	1	5	1	5	5	7	7	5
S	A	2	1	1	4	2	6	6	6	7	7
S	A	2	1	1	4	1	7	7	7	7	6
S	A	2	1	1	3	2	7	5	6	7	6
S	A	2	1	1	4	1	5	5	7	2	1
S	A	3	1	1	4	1	7	7	6	7	7
S	A	3	1	1	7	1	6	4	7	7	1
S	A	2	1	1	2	1	5	2	6	7	3
S	A	2	1	1	4	2	5	5	6	7	5
S	A	2	1	4	3	3	5	3	4	7	7
S	A	2	1	1	7	1	5	5	5	7	4
S	A	3	1	1	4	1	6	5	4	6	4
S	A	3	1	1	3	1	5	5	5	6	5
S	A	5	1	1	2	2	7	6	5	7	5
S	A	2	1	1	7	2	7	7	4	7	7
S	A	2	1	1	6	2	6	6	6	7	6
S	A	3	1	1	7	1	6	5	4	6	6
S	A	2	1	1	4	1	6	5	4	7	4
S	A	3	1	1	2	2	7	7	7	7	6

S	A	2	1	1	6	1	5	7	7	7	7
S	A	3	1	1	5	1	7	5	5	7	7
S	A	3	1	1	2	1	7	7	6	3	5
S	A	5	0	1	6	1	7	7	7	7	7
S	A	2	0	1	3	1	4	4	5	7	3
S	A	2	0	1	5	1	5	5	4	7	5
S	A	2	0	1	7	1	7	7	7	7	7
S	A	2	0	1	5	1	7	7	7	7	7
S	A	3	0	1	6	1	4	4	2	2	2
S	A	2	0	1	1	1	5	5	2	7	4
S	A	2	0	1	6	1	5	5	7	7	2
S	A	2	0	1	7	1	7	7	7	7	7
S	A	2	0	1	4	1	4	4	4	7	7
S	A	2	0	1	5	1	7	5	5	7	5
S	A	2	0	1	3	3	5	5	4	7	3
S	A	2	0	1	5	1	7	7	7	7	6
S	A	2	0	1	2	2	6	7	5	6	4
S	A	3	0	1	1	2	1	2	2	7	1
S	A	4	0	1	7	2	4	4	3	6	5
S	A	2	0	1	4	1	4	4	5	5	5
S	A	2	0	1	5	1	7	7	3	7	5
S	A	2	0	1	2	1	6	6	6	6	7
S	A	2	0	1	7	3	7	7	7	7	7
S	A	2	0	1	2	1	5	5	6	7	1
S	A	2	0	1	5	3	7	7	7	7	5
S	A	2	0	1	2	1	2	2	2	3	1
S	A	3	0	1	2	1	3	3	3	4	3
S	A	2		1	6	1	5	4	4	7	6
S	A	4		1	3	1	3	3	3	7	2
S	A	2		1	5	2	6	6	4	7	5
S	B	5	1	5	5	4	7	7	7	7	7
S	B	4	1	1	6	1	2	2	6	6	3
S	B	3	1	1	5	1	6	6	6	7	5
S	B	4	1	1	2	1	7	7	7	7	7
S	B	3	1	1	3	2	7	7	7	7	7
S	B	2	1	1	6	1	7	7	7	7	7
S	B	3	1	1	5	2	5	4	3	7	2
S	B	3	1	1	4	1	4	4	4	2	1
S	B	3	1	1	7	1	1	1	6	7	4
S	B	2	1	1	6	1	7	7	7	7	7
S	B	3	1	1	4	1	5	5	2	4	3
S	B	2	1	1	3	1	6	6	6	7	5
S	B	2	1	2	7	5	7	7	7	7	7
S	B	2	1	1	5	1	5	5	5	7	5
S	B	3	1	1	7	1	5	5	5	5	5
S	B	3	1	1	6	1	2	2	2	5	5
S	B	2	1	1	5	1	7	5	3	7	6
S	B	2	1	1	3	2	6	6	5	7	4
S	B	2	1	1	2	2	6	5	5	6	3

S	B	2	1	1	3	3	3	3	3	6	4
S	B	2	1	1	5	1	7	7	7	7	7
S	B	3	1	1	2	1	7	7	5	7	7
S	B	2	1	1	5	1	7	7	7	7	4
S	B	2	1	1	6	1	7	7	7	7	6
S	B	2	1	1	1	1	6	6	5	7	4
S	B	3	1	1	4	1	5	5	5	7	7
S	B	2	1	1	5	2	2	2	2	6	2
S	B	2	1	1	6	1	6	5	3	7	7
S	B	2	1	1	4	1	4	4	4	7	4
S	B	2	1	1	4	1	6	6	6	6	6
S	B	2	1	1	1	1	5	5	5	2	1
S	B	2	1	2	5	1	7	7	7	7	7
S	B	3	1	1	6	1	6	6	6	7	5
S	B	3	1	1	6	4	6	5	5	7	4
S	B	3	1	1	5	1	7	7	7	7	7
S	B	3	1	1	3	2	7	7	4	7	7
S	B	2	1	1	3	1	3	3	4	6	4
S	B	3	1	1	4	1	7	7	7	7	7
S	B	2	1	1	4	1	5	4	3	5	3
S	B	2	1	1	5	1	6	6	5	7	6
S	B	2	1	1	2	1	6	6	2	7	4
S	B	3	1	1	2	1	5	6	5	4	6
S	B	2	1	1	3	2	3	2	1	2	1
S	B	2	1	1	7	1	7	7	7	7	7
S	B	3	1	1	5	1	5	6	7	7	3
S	B	2	1	1	7	1	7	7	7	6	5
S	B	2	1	1	5	1	7	7	6	7	6
S	B	4	1	1	1	1	6	5	7	7	6
S	B	3	1	1	5	1	7	6	5	7	6
S	B	3	1	1	4	2	4	4	3	4	3
S	B	2	1	1	2	1	7	7	7	7	5
S	B	3	1	1	1	3	1	1	1	1	1
S	B	2	1	1	5	1	7	6	7	7	4
S	B	2	1	1	5	1	6	5	1	7	5
S	B	2	1	1	7	1	4	4	5	6	4
S	B	3	1	1	3	2	5	5	4	7	7
S	B	3	1	1	3	1	5	6	6	6	6
S	B	2	1	1	3	1	6	6	7	6	2
S	B	2	1	1	5	1	7	7	7	7	6
S	B	2	1	1	3	1	6	6	5	7	7
S	B	2	1	1	7	1	7	7	7	7	7
S	B	2	1	1	6	1	7	7	7	7	7
S	B	2	1	1	2	1	5	6	6	7	7
S	B	2	1	2	7	1	7	5	5	6	6
S	B	3	0	1	5	1	4	4	5	7	4
S	B	2	0	2	4	1	4	3	4	1	3
S	B	2	0	1	3	2	7	7	7	7	7
S	B	2	0	1	3	3	5	3	5	7	7

S	B	2	0	1	4	1	4	4	5	5	5
S	B	2	0	1	7	4	4	4	4	7	3
S	B	2	0	1	3	1	3	3	3	3	3
S	B	2	0	1	3	1	7	7	4	7	3
S	B	2	0	1	3	1	7	7	6	7	5
S	B	2	0	1	5	1	4	4	4	7	4
S	B	2	0	1	6	1	6	6	6	6	6
S	B	2	0	1	3	1	4	5	5	6	5
S	B	2	0	1	5	1	5	5	5	6	3
S	B	2	0	1	1	1	7	7	4	7	5
S	B	3	0	1	3	3	4	4	3	3	2
S	B	2	0	1	4	1	7	7	7	7	7
S	B	4	0	1	4	2	4	4	4	7	4
S	B	3	0	1	5	1	6	6	4	6	5
S	B	2	0	1	3	4	6	5	4	7	4
S	B	2	0	1	2	2	7	6	4	7	4
S	B	2	0	1	6	1	5	5	7	7	6
S	B	2	0	1	5	1	1	1	7	7	2
S	C	5	1	5	6	4	7	7	7	7	7
S	C	4	1	1	6	1	7	6	6	7	5
S	C	4	1	1	6	5	6	6	6	6	4
S	C	3	1	3	4	1	6	6	5	7	6
S	C	2	1	1	7	1	7	7	7	7	7
S	C	2	1	1	5	1	5	5	6	7	6
S	C	2	1	1	6	3	5	6	5	7	4
S	C	2	1	1	7	1	3	4	1	6	1
S	C	2	1	1	6	1	7	7	5	7	6
S	C	2	1	1	2	1	6	6	6	4	6
S	C	3	1	1	1	1	7	7	7	7	7
S	C	2	1	1	4	1	4	4	4	4	4
S	C	3	1	1	2	1	2	2	1	1	1
S	C	2	1	1	4	2	3	5	3	4	3
S	C	2	1	1	2	1	5	4	2	7	1
S	C	2	1	1	4	1	6	6	6	7	6
S	C	3	1	1	5	1	7	7	7	7	7
S	C	2	1	1	2	1	7	7	7	7	7
S	C	4	1	1	3	3	3	3	3	3	3
S	C	2	1	1	2	1	7	7	5	7	7
S	C	2	1	1	5	1	6	6	5	6	7
S	C	2	1	1	2	1	2	2	2	2	2
S	C	3	1	1	5	2	5	5	4	6	5
S	C	2	1	1	3	2	4	4	4	4	4
S	C	2	1	1	5	2	6	5	4	7	3
S	C	2	1	1	2	1	2	2	2	2	2
S	C	3	1	1	6	2	6	6	6	7	4
S	C	3	1	1	6	1	6	5	6	6	4
S	C	2	1	1	6	1	7	7	7	7	5
S	C	3	1	1	7	1	5	5	5	7	6
S	C	3	1	3	1	2	7	7	7	7	4

S	C	3	1	1	4	1	6	5	4	7	3
S	C	3	1	1	6	3	7	6	4	7	5
S	C	4	1	1	6	1	6	6	7	7	5
S	C	3	1	1	5	2	5	4	3	5	5
S	C	3	1	1	7	1	7	7	7	7	7
S	C	2	1	1	5	4	4	4	4	2	2
S	C	2	1	1	1	1	3	3	3	3	2
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NoS	-	4	1	2	7	4	7	7	7	7	7
NoS	-	2	0	5	5	1	5	5	4	7	5
NoS	-	1	1	4	3	5	1	1	1	1	1

Supplementary Table 7.2. Post-hoc Tukey tests comparing pro-environmental behavior intentions in Study 1 (Control group of students, *n* = 83, and Non-students reference group, *n* = 247). Student's *t* values and their corresponding *p*-value are respectively below and above the diagonal. Significant values are marked in bold.

	Reduce plastics	**Refuse MP**	**Replace**	**Recycle**	**Pro-environmental engagement**
Reduce plastics		2.05	0.21	**0.02**	**0.000**
Refuse MP	0.59		0.96	**0.000**	**0.011**
Replace	3.00	0.95		**0.000**	0.08
Recycle	**4.31**	**6.36**	**7.31**		**0.000**
Pro-environmental engagement	**6.61**	**4.56**	3.60	**10.91**	

Supplementary Table 7.3. Two-way ANOVA testing differences among treatments and types of behavior for the mean intention to undertake R-behaviors in Spanish university students.

	Sum of squares	**d.f.**	**Mean square**	***F***	***p* value**
Factor treatment	42.84	3	14.28	5.01	0.002
Factor behavior	283.83	4	70.96	24.87	0.000
Interaction	10.39	12	0.87	0.303	0.989
Within	4565.03	1600	2.85		
Total	4902.08	1619			

Supplementary Table 7.4. Post-hoc pairwise tests comparing pro-environmental behavior intentions in this experiment. Student's *t* values and their corresponding *p*-value are respectively below and above the diagonal. Significant values are marked in bold.

	Reduce plastics	**Refuse MP**	**Replace**	**Recycle**	**Pro-environmental engagement**
Reduce plastics		0.66	0.054	**0.000**	**0.000**
Refuse MP	1.91		0.66	**0.000**	**0.02**
Replace	3.81	1.91		**0.000**	0.44
Recycle	**6.9**	**8.81**	**10.71**		**0.000**
Pro-environmental engagement	**6.21**	**4.3**	2.4	**13.11**	

Supplementary Table 7.5. Post-hoc Tukey's test of repeated measures ANOVA comparing treatments. Pairwise t-test comparing the experimental groups. A: contaminated seafood; B: plastics in sea bottom; C: dead seagull with plastic ropes; Control. Significant values are marked in bold.

	A	**B**	**C**	**Control**
A		0.344	**0.0006**	**0.0006**
B	2.468		**0.008**	**0.007**
C	**8.157**	**5.689**		0.99
Control	**8.243**	**5.775**	0.086	

Supplementary Table 7.6. Multiple regression analysis showing the effect of socio-demographic variables, personal responsibility attribution, treatments and MP awareness measured as microbead checking, on the mean of R-behaviors in the whole sample. SE, standard error. Significant variables are marked in bold italics.

	Coefficient	**SE**	***t***	***p***	**r^2**
Dependent variable: Mean of R-behavior intentions	***3.081***	***0.277***	***11.13***	***0.000***	
Independent variables:					
Age	0.077	0.047	1.624	0.105	0.001
Education level	0.04	0.067	0.596	0.552	0.0002
Gender	***0.354***	***0.114***	***3.112***	***0.002***	***0.022***
Microbead check	-0.006	0.057	0.111	0.912	0.00002
Personal responsibility	***0.383***	***0.03***	***12.784***	***0.000***	***0.201***
Treatment	***0.165***	***0.059***	***2.784***	***0.006***	***0.009***