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Literature Review

Presence of Plastic Microparticles in Chile: Human Health Risk

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Abstract

Current investigations concerning the abundance and distribution of microplastics in different bodies of water and biota throughout the world include very few studies conducted in Latin America. However, the occurrence, transportation and fate of microplastics present in the environment could have potential health impacts of the population exposed to the consumption of food contaminated with microplastics. These materials include in their composition several persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH), phthalates and others, all of them known as endocrine-disrupting chemicals (EDC). This review presents current studies and advances on the subject in Chile, a country with a large coastal area, by compiling the research carried out to date in the region.

Keywords: *Microplastics; Contamination; Health Risk; Chilean Coasts; Chilean Soils; Persistent Organic Pollutants*

Abbreviations

MPs: Microplastics; PAH: Polycyclic Aromatic Hydrocarbons; PBDEs: Polybrominated Diethyl Ethers; PCBs: Polychlorinated Biphenyls; EDC: Endocrine Disruption Chemicals; POPs: Persistent Organic Pollutants; PE: Polyethylene; PET: Polyethylene Terephthalate; CEAZA: Center for Advanced Studies in Arid Zones; ESMOI: Millennium Nucleus Center of Ecology and Sustainable Management of Oceanic Islands; PFASs: Perfluoroalkyl Substances; PM: Particulated Matter

Introduction

The omnipresence of microplastics (MPs, plastic particles < 5 mm) represents the largest proportion of plastic debris in the global biosphere and is raising increasing concerns about their implications for human health [1,2]. Plastic is one source of chemical exposure, with a global production of almost 360 million metric tons in 2018. More than 900 chemicals likely associated with plastic and, 63 chemicals that ranked highest for human health concerns underwent a tiered prioritization based on biomonitoring data, endocrine disrupting properties, and their regulatory status [3]. Endocrine disruption compounds (EDC) refer to environmental factors that interfere with hormone metabolism and homeostasis, a process that might explain developmental programming by prenatal chemical exposure [4]. Only 30% of the world's countries have reported research on MPs and their effects, with countries from Europe (38%) and Asia (36%) regions contributing to the studies [5]. In contrast, research in Latin America has only just begun and is limited to countries such as Argentina, Brazil, Chile, Colombia and Mexico.

Although Latin America shares 4% of the production and 8% of the total consumption of plastics worldwide, the physical-chemical nature of PMs has become a major public health problem worldwide due to its high stability, low degradation, high toxicity, and persistence in the environment. This means that MPs can travel far from their sources acting as vectors and their populations can be equally affected by their contamination.

Materials and Methods

There is a growing amount of research on the abundance and distribution of microplastics in different bodies of water and biota around the world and their consequences. However, in Latin America and Chile, there is little data available on the presence of MPs in the human diet. Therefore, in this review, a broad and indirect approach was adopted to analyze articles on the presence of PM in the territory and coasts of Chile since 2010. More than 60 articles were classified by combining the keywords "microplastic contamination", "health risk" and "Chile" in the Scopus (Elsevier's Scopus) and Google Scholar databases.

Results and Discussion

The accumulation of MPs in the marine environment has been a long-known problem. Due to their small size, they are easily ingested by marine fauna and can accumulate in the food web, along with associated toxins and microorganisms that colonize plastic [6,7]. The results of experimental studies on the abundance of MPs in the Pacific Ocean using a numerical model suggested that the concentrations of pelagic MPs around the subtropical convergence zone would approximately double (four times) by 2030 from the current condition [8]. The coast of continental Chile extends from 18° S to approximately 56° S and is approximately 4200 km long, and although the main populated areas are concentrated between 33° S and 35° S in central Chile, the discharges of MPs waste can be transported long distances by ocean currents, affecting not only the coast but deep waters of the South Pacific.

An investigation on the transport dynamics of MPs in the coastal ocean that evaluated the occurrence and distribution in the water column in the fjords of the Chilean Patagonia (Chile) and its potential use of MPs as vectors of persistent organic (POPs). These are a group of potential EDC that are toxic, persistent, and are able to bioaccumulate and move long distances using natural processes on soil, water, air, and biota. It includes polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), polybrominated diethyl ethers (PBDEs), polyfluorinated compounds (PFC), phthalates, organochlorine pesticides (OCPs). Polyfluorinated compounds, one of the pathways by which PFC can be taken up is through the ingestion of contaminated foodstuffs, and plants (e.g. grains). Plants can take up PFC from contaminated soils. Sheringer., *et al*. [9] concluded that 90% of all PFC exposure is derived from food and dietary intake. By another hand, phthalates are a family of artificial chemicals that have applications as plasticizers in polyvinylchloride (PVC) materials such as food packaging. They are classified as EDC and, have been linked to adverse health effects, particularly about early-life exposure [10]. Today, humans are exposed to PCBs, PBDEs, and OCPs by breastfeeding and the consumption of fish, meat, and dairy products [11,12].

The microplastic particles can function as vectors of persistent organic pollutants (POPs) in the coastal ocean, depending on polymer properties and environmental variables. The distribution and abundance of MPs in the water column along a large remote estuarine system located between the North and South Patagonian Ice Fields in Chilean Patagonia that connects to the Pacific Ocean showed polymers such as acrylic, polyethylene terephthalate and cellophane. The higher abundance of MPs observed in the deeper waters towards the Gulf of Penas points to groundwater intrusions that transport plastic particles from the ocean to the channel system [13,14]. A study of sediments collected on the coast of Chiloe (Chile) detected MPs particles in 35 stations, consisting mainly of fibers (88%), fragments (10%), and films (2%). The distribution and abundance of MPs are explained by the proximity and intensity of local salmon production activities [15,16].

Studies by Pozo., *et al.* in a coastal area of central Chile (San Vicente Bay) detected the compounds, polybrominated diethyl ethers (PBDEs), polychlorinated biphenyls (PCBs), and organochlorine pesticides (OCPs) in plastic resin granules, probably influenced by the presence of industrial activities in the surrounding area. Plastic resin has a high adsorption capacity, so it may be able to transport (persistent organic pollutants, POPs) to coastal environments [17]. In another study, polymers such as polyester, polyethylene (PE), and polyethylene terephthalate (PET) were detected in MPs particles in six commercially important fish species in central Chile (Biobío region), which shows the potential risk of the population who consumes these marine products and the impact of MPs in Chilean fishing activities [18].

The importance of knowing in detail the cycle of MPs particles in the marine environment to assess the biological impacts of MPs in marine organisms must consider not only the risk of the species themselves but also the implications at the higher levels of the trophic chain [19-22]. Some studies on the southern coasts of the Pacific Ocean show that the density of the MPs influences their dispersal capacity, being able to be transport long distances and accumulation in convergence zones such as subtropical gyres or sinks in the water column [23-25].

Studies by Pannetier., *et al*. in Easter Island (Rapa Nui) in the southeastern Pacific Ocean 3900 km off the Chilean coast showed ingestion and toxicity in the early life stages of fish at realistic concentrations of MPs particles [26-28]. Alternatively, in Northern Chilean Patagonia, similar studies have been conducted in a population of *Arctocephalus australis* (sea lions) that showed a remarkable abundance of microfibers [30]. Andrade and Ovando reported MP particles in the stomach content of the king crab *Lithodes santolla*, which could present a risk not only for the species itself, but also for other trophic levels in the food web [20].

Pollution in a certain area is related to territorial organization, activities and land use [31,32]. Thus, the combination and interaction of MP particles with contaminants that they absorb can affect health, soil function, and even migration along the food chain. Only recently has the relevance of this contamination in the terrestrial system been recognized as a possible source that contributes MPs particles to rivers and oceans. The little interest between economic development and environmental problems in Chile calls for further studies and research [33-35]. Chilean agriculture has made it a common practice to use sludge from water treatment plants on agricultural soils as fertilizer. Corradinni., *et al*. have studied MP contamination of soil by this practice, evaluating the implications of this practice by observing the total count of MP particles in soil samples, and finding evidence of MP contamination in croplands, and grasslands [36-38]. A study on the effects of exposure to MPs in soil samples from an organic farm in the city of Chillan (Ñuble Region, Chile), demonstrated that *Lumbricus terrestris* functioned as a suitable bioindicator to test the contamination by MPs in soils [39].

The assessment of the production of publications on MPs considers China, USA, and Germany as the main players. However, Portugal, Chile, and Ireland are among the top countries where socioeconomic characteristics and research expenditures are included. In Chile, concerning MP investigations, there are some publications from the Center for Advanced Studies in Arid Zones (CEAZA) and the Millennium Nucleus Center of Ecology and Sustainable Management of Oceanic Islands (ESMOI) [40,41]. Limited studies and the lack of standardized methodologies make it difficult to establish fundamental information on the abundance and types of MPs in most countries in this region [42,43]. The quantification of the research in these aspects would allow propose a threshold level of MPs and formulate control measures to reduce the use of plastics and compromise the affected communities [44-47]. A group of Chilean scientists working on plastic pollution has created the Chilean Plastic Pollution Scientific Alliance network to promote collaborative and coordinated research focused on these pollutants. Chile's vast geographic spread, with researchers working in diverse ecosystems, provides a unique opportunity to better understand the consequences of one of the most recent and serious threats to biodiversity [48].

It is hoped that this review will serve to understand that efforts to address the health hazards of MPs must be approached multidisciplinary. In addition to showing the scarce and insufficient research in the region, which would prevent the support of mitigation strategies and the formulation of sound health policies [49].

Conclusion

The spread and impact of MPs have come under scrutiny. First, intentional MP additives are being considered for the ban due to their negative impact on human and animal health, and second, products that release MPs upon normal use may eventually must switch to non-persistent polymers that biodegrade in the environment within a finite and acceptable period. Design rules must to anticipate the emergence of new technologies in identification/sorting and chemical recycling. They also need to consider the biodegradation of the small fraction of products that, despite all efforts, will still be released into the environment and will generate MPs.

Conflict of Interest

The authors declare no conflict of interest.

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