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ARTICLE REVIEW

Microplastics, an emerging public health problem

Microplásticos, un problema de salud pública emergente

Microplásticos, um problema emergente de saúde pública

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ABSTRACT

Introduction: commercial plastic products has transformed the modern era in such a way that current life without plastic would not be possible, so at the same time with this development, plastics contamination is present, becoming one of the most urgent environmental problems nowadays. **Objective:** to gather available information published on the last five years concerning the microplastics as a source of environmental contamination in Ecuador and in order to reinforce the local interest on plastic pollution. **Development:** an unstructured review of the literature was performed. Databases used, PubMed and Google Scholar. The inclusion criteria used were as follow: articles in English and Spanish published on the last 5 years, no other language; study selections have been done by convenience. It was chronologically organized and analyzed the evidence published in PubMed and Google Scholar on the last five years concerning the microplastics behavior in Ecuador. **Final considerations:** the information collected chronologically shows the advancing pollution caused by microplastics both globally and in Ecuador, in addition, the presence of microplastics in oceans, fresh water, terrestrial ecosystems, air, foods and even in the human body is evident. Therefore, contamination caused by microplastics is a topic of a great importance today, which requires a speedy control action.

Keywords: toxic; pollution; environment; public health; waste; microplastics

RESUMEN

Introducción: los productos plásticos han transformado la era moderna de tal manera que la vida sin plásticos sería irreconocible, a la par de este desarrollo la contaminación plástica es omnipresente convirtiéndose en uno de los problemas ambientales modernos más importantes. **Objetivo:** compilar la información publicada en los últimos cinco años sobre la contaminación ambiental por microplásticos en Ecuador para reforzar el interés local sobre estos contaminantes. **Desarrollo:** se realizó una revisión no estructurada de la literatura. Se utilizaron como bases de datos PubMed y Google Scholar. Los criterios de inclusión fueron: artículos publicados en los últimos 5 años, en idiomas inglés y español, se excluyeron otros idiomas; la selección de estudios fue de tipo a conveniencia. Se organizó y analizó cronológicamente la evidencia publicada en PubMed y Google Scholar en los últimos 5 años sobre microplásticos en Ecuador. **Consideraciones finales:** la información recopilada muestra cronológicamente el avance de la contaminación por microplásticos tanto a nivel mundial como en Ecuador, además, se evidencia la presencia de microplásticos en océanos, agua dulce, ecosistemas terrestres, aire, alimentos y dentro del cuerpo humano. Por lo cual la contaminación por microplásticos es un tema de gran relevancia actual, que requiere acciones de control inmediatas.

Palabras clave: tóxicos; contaminación; medio ambiente; salud pública; residuos; microplásticos

RESUMO

Introdução: os produtos plásticos transformaram a era moderna de tal forma que a vida sem plásticos seria irreconhecível, junto com esse desenvolvimento, a poluição plástica é onipresente, tornando-se um dos mais importantes problemas ambientais modernos. **Objetivo:** compilar as informações publicadas nos últimos 5 anos sobre a contaminação ambiental por microplásticos no Equador para reforçar o interesse local por esses contaminantes. **Desenvolvimento:** foi realizada uma revisão não estruturada da literatura. Foram utilizadas as bases de dados PubMed e Google Scholar. Os critérios de inclusão foram: artigos publicados nos últimos 5 anos, nos idiomas inglês e espanhol, foram excluídos outros idiomas; a seleção dos estudos foi do tipo conveniência. As evidências publicadas no PubMed e Google Scholar nos últimos 5 anos sobre microplásticos no Equador foram organizadas e analisadas cronologicamente. **Considerações finais:** as informações coletadas cronologicamente mostram o progresso da contaminação por microplásticos tanto no mundo quanto no Equador, além disso, é evidente a presença de microplásticos nos oceanos, água doce, ecossistemas terrestres, ar, alimentos e dentro do corpo humano. Portanto, a contaminação por microplásticos é um tema de grande relevância atual, que requer ações imediatas de controle.

Palavras-chave: tóxico; poluição; meio ambiente; saúde pública; desperdício; microplásticos

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INTRODUCTION

Plastics are synthetic polymers of great versatility, durability and low production cost that have replaced traditional materials in an endless number of uses. Their advantages in industry are, at the same time, their main disadvantage, since they have a slow degradation, remaining hundreds of years in the environment once discarded and generating plastic waste of smaller size that are currently known as microplastics (MP).

MP pollution, which are plastic particles smaller than 5 mm(1) is secondary to the indiscriminate use of products made of this material worldwide and their degradation residues,(2) which are considered toxic substances. It currently represents an emerging threat to public health worldwide.

The first publications on microplastics in the marine environment appeared in the 1970s and analyzed contamination from primary plastic sources, such as resin granules in water and on beaches.(3)

So far, MP has been analyzed in sediments and water from a wide variety of coastal areas all over the world, from very remote to densely populated areas.(3)

The slow degradation of MP and its consequent accumulation in ecosystems is a major threat to the environment,(4) since one of the main problems of plastic products is that they have a very short shelf life and are disposable, yet they persist in the environment for hundreds of years with little or no degradation, which impacts ecosystems and humans, with effects still unknown.

The rapid increase in the production of disposable plastic products and their accumulation in the environment has outstripped the capacity to manage them properly, and this is most visible in developing countries in Latin America, Asia and Africa, where waste collection and recycling systems are inefficient or non-existent.(5)

The problem also extends to developed countries with high rates of plastic waste production. Therefore, understanding the ubiquity of the problem, as well as the need to disseminate quality information about it, will allow to raise awareness and visualize it as a priority for public health care, these characteristics make this topic relevant and pertinent today.

Therefore, it was decided to compile the information published in the last five years on environmental contamination by microplastics in Ecuador to reinforce local interest in these pollutants.

DEVELOPMENT

The present work is an unstructured review of the literature on microplastics. PubMed and Google Scholar were used as databases. The inclusion criteria were: articles published in the last five years, in English and Spanish, other languages were excluded; the selection of studies was based on convenience.

Microplastics, global relevance

Since the 1960s, the world production of plastics has grown by 9 % per year. Of this production, it is estimated that about 8 million tons per year are discharged into the marine environment[6] and the demand for plastic products worldwide continues to increase. In Europe, it has been reported that industrially important plastics are mainly derived from low and high density polyethylene (17.5 % and 12.3 %, respectively).[7] Since 2004, several researches have raised alarms worldwide about the accumulation of plastic waste in the seas, and consequently, the possibility of the entry of this toxic waste into the human food chain.[8]

Specific reports on MP in water, marine sediments and beaches of the Mediterranean Sea basin were published in 1979. These pioneering articles have served as a starting point for studies in other areas of the planet, generating references for estimating the magnitude of ecological damage at global level.[1]

Studies have estimated that there are between 70,000 and 270,000 tons of floating plastic debris in the sea.[9] Considering that plastic particles vary in size and weight, it is estimated that only approximately 1% of the plastic introduced into the seas can be observed as floating debris;[9] there is a significant accumulation of this type of debris on the seabed.

Attention to environmental pollution by MP continues; MP has now been reported in all the world's oceans,[10] in freshwater sources and in terrestrial ecosystems.[11] As a relatively new concept, there are no agreed definitions of the size of these contaminants. At the First International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine in 2008 agreed on the existence of the nomenclature: microplastics (plastic particles >100 nm up to 5 mm) and nanoplastics (plastic particles <100 nm).[12]

It is safe to say that the only origin of environmental contamination by plastics is human activity.[13] The growing interest in this subject has been reinforced due to the evidence of their toxic effects on the affected ecosystems. There are reports of direct damage to living beings by ingestion, strangulation, entrapment, in addition to being vehicles of invasive species or other pollutants such as hydrocarbons, polychlorinated biphenyls or dichlorodiphenyltrichloroethane, both in seas and terrestrial ecosystems.[14]

In 2019, the ability of MP to adsorb chemical pollutants such as metals or pharmaceuticals in seawater, urban wastewater and irrigation water was studied in China. The results revealed significant adsorption of toxicants such as lead, chromium and zinc on MP, especially, those formed by polyethylene and polyvinyl chloride.[15]

These findings have been complemented by subsequent studies that evaluated the adsorption of plastic molecules to antibiotics such as levofloxacin and interesting data were reported, for example: that the presence of certain metals such as copper, zinc and chromium promote the adsorption of antibiotics to the surface of microplastics,[16] this has generated great concern in the world scientific community since MP are presented as coadjuvants in the generation of bacterial resistance.

Several *in vitro* studies in human cells and in live rodents have demonstrated the potential of inhaled or ingested MP to cause a variety of biological effects including: neurotoxicity, metabolic alterations, physical toxicity, oxidative stress, cytokine secretion, cell damage, inflammation, DNA damage and immune reactions,(11) in addition to proinflammatory and oxidative intestinal states, results that have progressively increased the scientific evidence linking the toxic potential of MP with the generation of chronic immune disorders.(17)

Previously, the oceans were considered to be the reservoirs most affected by bioaccumulation of microplastics. It is now recognized that MP can be found in all environments.(18) For example, there are studies that have researched the effects of microplastics derived from surgical masks (objects made of plastic polymers) on earthworms, which showed high concentrations (1 000 mg/kg dry soil), MP have generated inhibition of reproduction and growth in earthworms, intracellular decrease of esterase enzyme activity and inhibition of spermatogenesis in male earthworms,(19) which affects terrestrial ecosystems and species.

On the other hand, the presence of MP in the air has also been studied. The concentration of people in cities has reduced the habitable spaces in them, turning them into overpopulated places with increasingly smaller living spaces. This, added to important changes in lifestyles such as sedentary lifestyles, work activities limited to indoor spaces with almost no exposure to fresh air and long working hours, among others, produce prolonged exposures to closed environments.(11)

The aforementioned characteristics have awakened interest in indoor air pollutants, where dust particles were previously considered to be the main problem; however, it has recently been demonstrated that indoor air pollution with MP exists.(18)

There can be several sources of MP in indoor environments, for example, abrasion of plastic materials, painting of objects and furniture, waste derived from modern work activities such as 3D printing, which use plastic polymers as raw material and are carried out in closed environments. Furthermore, it is important to know that tire abrasion is the main source of MP in cities.(20) Based on the above data, it can be said that MP are nowadays omnipresent,(21) even being found inside human beings.

Recent research has reported the identification, for the first time, of MP in human placental samples, both maternal and fetal, as well as in chorioamniotic membranes.(1) These findings denote a tissue accumulation of MP secondary to systemic exposure. Such factors should provoke deep reflections and health alarms about physical, chemical and microbiological toxicity secondary to MP, as well as its long-term effects.

Similarly, recent studies have identified MP in feces, which reinforces the knowledge that the ingestion of these toxic materials is ongoing and requires further research.(22)

The initial concern about MP entering the human diet has been confirmed, and it is estimated that after ingestion, MP particles can reach the brain. Although there is little information on their actual neurotoxicity potential, the presence of these toxicants induces oxidative stress, inhibition of acetylcholinesterase enzyme activity and alteration of neurotransmitter levels, factors that result in cell damage and increased vulnerability to develop neuronal disorders, leading to behavioral changes.[23]

We can also say that the COVID-19 pandemic aggravated the situation, given that the massive use of masks made of plastic polymers (polypropylene) has meant the worldwide generation of even more plastic waste, which, due to deficient control strategies regarding their final disposal, will end up accumulating in the environment.

Since the end of 2019, millions of disposable masks are consumed daily worldwide.[24] Although they are among the most efficient protective equipment to mitigate the spread of COVID-19, along with social distancing and contact transmission preventions such as hand washing, masks are made of plastic polymers and are mostly disposable and single-use products, which makes them a new source of massive and recurrent waste.

It has been identified that each mask can release more than 1 billion particles of nanoplastics and MP. MP was detected in the nasal mucus of mask wearers, which can be inhaled and ingested while wearing this protective equipment. This information is useful, as it allows considerations of the possible risks associated with long-term use of masks.[4]

These data became relevant already at the beginning of the COVID-19 pandemic in 2020, when OceansAsia, a marine pollution research organization reported the presence of masks of different types and colors in Hong Kong oceans.[4]

Therefore, the potential harmful effect of MP pollution on the environment is evident, and although disposable masks have been a useful, inexpensive and widely used means of protection as a new social norm in the context of the pandemic, they must be accompanied by information for proper disposal, which generates environmental responsibility.[25]

All the data analyzed demonstrate that MP represents a significant environmental toxic effect and a challenge to public health, both now and in the future.[26]

Microplastics in Ecuador

In 2011, the assessment of the concentration of organophosphates and microplastics in water and sediments from burrows and tissues of fiddler crabs *Leptuca festae* and *Minuca ecuadoriensis* from Santay Island of the Guayas River, Ecuador, was published. The results showed concentrations up to 26 times above the thresholds for chronic exposure to organophosphates in water and sediments of fiddler crab burrows, demonstrating environmental risk.[27]

On the other hand, MPs were found in tissues of both crab species, mainly in the gills, digestive tract and hepatopancreas. Fiddler crabs are species that are chronically exposed to environmental contamination, so they are considered suitable bioindicators for monitoring Santay Island and understanding human impacts on Ecuador's coastal environments.[28]

In 2019, the presence of MP in drinking water was assessed in Riobamba, Ecuador. The results of the study indicated that 80% of the samples analyzed had the presence of MP, in addition to indicating that in the absence of standard parameters on toxicity levels, it can be concluded that the amount and type of PM found in the samples analyzed represent a health risk to exposed animals and humans.(6)

The presence of MP in high mountain ecosystems was already studied in 2020, considering that wind can transport and deposit MP in these ecosystems. Knowing that mountain glaciers are the main source of drinking water for large urban areas in the Andes Mountains, the assessment of MP is of great importance. Three surface samples of snow and ice taken from the Antisana glacier were analyzed and 270 mps/ML of analyzed sample were found. The size of the MPs ranged from 60 to 2500 µm. The abundance of MPs found in the samples was substantial, confirming the hypothesis that MPs are being transported from multiple sources and have been deposited on the glacier over time,(29) thus establishing a source of contamination of drinking water in urban areas of Quito, Ecuador.

The presence of MP in processed foods in Ecuador has also been analyzed in this same 2020; after analyzing honey, beer, milk and soft drinks, an average of 40 MP/L was reported. The results showed a higher presence of MP compared to the European record, probably due to the processing methods.(30)

The first evaluation of MP contamination in the coastal zone of Esmeraldas Province, Ecuador was published in 2022. The results showed PM contamination in 84 % of the total analyzed, reporting that MP contamination is generalized and its sources are multiple.(31)

In the same year 2022, another MP study in Ecuador reported on the distribution and composition of MP on two beaches in the Galapagos Islands, a world-renowned and valued tourist destination. The data showed a high MP concentration of 0-2 524 particles/m2 on the beaches analyzed. One of the most troubling findings of this study was the report of four times higher concentrations of MP in sea turtle nesting habitat on the beaches analyzed.(32)

The reports cited above show that like other places in the world, MP is present in Ecuador in all ecosystems; from the glaciers of the Andes Mountains, urban areas, to beaches and seas. The presence of MP has also been demonstrated in drinking water, and even in processed foods, becoming a priority threat to public health in the country and the world, a problem that increases due to the absence of regulations for proper management of these toxic wastes in the country.

The global trend is clear; there is scientific evidence demonstrating the presence of MP in large quantities and in all ecosystems of the world. The variety of methodological designs of the published studies complicates the comparison of their results. As pointed out by Cincinelli, *et al.*(33) there is a lack of standardized sampling methods for collecting MP in surface waters. The most common method of MP identification is visual inspection of the collected material with a microscope, although it is increasingly common for MP to be confirmed using analytical techniques such as (Fourier-transform infrared spectroscopy/FTIR).

These difficulties are compounded by the reporting of findings in different units of measurement (MP/km^2, g/km^2, mg/m^3 and/or MP/m^3), lack of information on the size range of MP collected, the types of polymers or whether they are primary plastics, virgin plastic resin granules/microspheres or secondary particles resulting from waste erosion. This lack of standardization with respect to data reporting makes it difficult to estimate the potential impact of MP on surface waters, as noted by Everaert, *et al.*(34) in 2020.

The limitations of this review lie in the need for more studies in Ecuador, the general methodological heterogeneity of the different studies and the absence of local control regulations for proper management and final disposal of these toxic wastes, which favors the continuity of this problem. Therefore, there is a need for greater consensus in the design, analysis and determination of study methods, metric units, sampling, toxicological analysis, as well as greater standardization in the evaluation of ecological and sanitary risk in Ecuador and the world.

FINAL CONSIDERATIONS

The evidence compiled shows chronologically the advance of microplastic contamination, both worldwide and in Ecuador, as well as the presence of microplastics in oceans, fresh water, terrestrial ecosystems, air, food, and inside the human body.

MP contamination is an issue of great current relevance, which merits immediate control actions. The available information allows us to assess the seriousness of MP contamination and the need for the development of control policies regarding its use and disposal, as well as the need for further research on the possible effects on human health.

It is hoped that this work will generate the necessary repercussions to raise awareness about MP and its environmental implications in the face of this emerging public health problem.

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Conflict of interest:
The authors declare that there are no conflicts of interest.

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