Plastics and polystyrene: the animal species between life and death

Plásticos y Tecnopor: la especie animal entre la vida y la muerte

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Abstract

Research has determined that the use of plastic bags and polystyrene constitutes the greatest threat to humanity: it alters terrestrial ecosystems, enters food chains and deteriorates marine ecosystems. Contemporary societies produce 380 million tons of plastics annually, of which three quarters are destined for the garbage that invades the environment, is confused with food and affects marine flora and fauna. In addition, microplastics have grown exponentially in recent decades, reaching 5 and a half billion units that threaten human, animal and fish life. This calls for further development of technologies and policies to reduce their impact on the environment.

Keywords: plastic use; recycling; microplastics; intake; environmental pollution.

Resumen

La investigación ha determinado que el uso de las bolsas de plástico y tecnopor constituye la mayor amenaza para la humanidad: altera los ecosistemas terrestres, se introduce en las cadenas alimentarias y deteriora los ecosistemas marítimos. Las sociedades contemporáneas producen anualmente 380 millones de toneladas de plásticos, de las cuales las tres cuartas partes se destinan a la basura que invade el medio ambiente, se confunde con los alimentos y afecta a la flora y fauna marina. Además, los microplásticos han crecido exponencialmente en las últimas décadas, alcanzan 5 y medio billones de unidades que amenazan la vida humana, animal y piscícola. Esto exige mayor desarrollo de tecnologías y políticas para reducir su impacto en el medio ambiente.

Palabras claves: uso de plástico; reciclaje; microplásticos; ingesta; contaminación ambiental.

Introduction

The process of industrialization of natural resources, among other considerations, has generated the problem of plastics. Annually 380 million tons are produced, of which three quarters are destined for the garbage (Buteler, 2019) and its use has extended, apart from packaging, to the manufacture of industrial components for automotive, housing, clothing and all kinds of consumer goods, with a growth of 4% per year (Arandes *et al.*, 2004). The use of different plastics such as bags, tapes, covers and hoses in agriculture pollute the land (Zenner & Peña, 2013).

The process of environmental pollution by the use of plastic bags has increased significantly in recent decades (Cáceres et al., 2019). The crux of this problem is their unrestricted use and inadequate final disposal; it is not clearly conceived that plastic bags and other products of similar compounds decompose into microplastics (Asalde, 2018). The intake of microplastics in the sea reaches the level of plankton, benthic invertebrates and large mammals, releasing toxic substances and reducing the efficiency of physiological processes, with the consequent risk of death of the affected beings. (Elías, 2015).

This shows the levels of irresponsibility that human beings have committed with the care of the environment, the lack of environmental education that effectively modifies attitudes towards the use of plastics and the need for

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a strategy to replace these products with other biodegradable ones. Obviously, as awareness of this problem is growing, some criteria, proposals for solutions and legislative initiatives with a relative impact on society are being established.

The use of plastics

The use of plastics has become a recurrent aspect of human activity (Iannacone *et al*., 2019), se estima que el mundo produce 300 millones de toneladas al año (Elías, 2015), which generates an average 5-50 billion plastic fragments (Garcia, 2019) that affect animal tissues and deteriorate key functions that sustain health and biodiversity (H. Reyes et al., 2019) and threaten ecosystems around the planet (Rojo & Montoto, 2017).

Pollution levels in the seas are extremely high, coming mainly from the external environment (Burgos & Michilena, 2015) and 80% of plastics derive from land-based activities (Elías, 2015), reaching the sea 8 million tons of garbage per year (Greenpeace, 2016) and generating extremely serious damage to marine ecosystems (Socas, 2018) that will directly and indirectly impact the living condition of human beings themselves.

A main aspect of this marine pollution has to do with the fragmentation of plastics (Greenpeace, 2016), the residues of fishing nets fiber exist in greater proportion in the Peruvian coasts (Purca & Henostroza, 2017), microplastics constitute an increasingly evident threat in the Brazilian coasts (Olivatto et al., 2018), similar results have been estimated on two beaches southwest of the Punta del Diablo Uruguay (Rocha) seaside resort (Rodriguez, 2018), which calls for a change in the attitude of human beings for the preservation of the environment.

Thus plastic has become the preferred material of the industry during the last century, petroleum products (being so flexible and relatively inexpensive) generated a massive production that ended up flooding the planet with plastics (Shareyko & IIIарейко, 2020). Obviously, plastic bags fragment, degrade and disintegrate, but they do not decompose completely at the level of other biodegradable elements such as fertilizers. It remains for a long time in the environment as microplastics (Buteler, 2019).

Table 1. Evolution of the plastic problem.

Evolution of the problem	Hitos temporales
Plastic accumulated since its origin	7.8 billion tons
Beginning of large-scale production	Decade of the 50's 20th century
Environmental awareness	Decade of the 70's and 80's

Source: Elaboration of the authors

In this process, the aspect to take into account is the long degradation process of these products that do not allow an ecological assimilation. Plastics take about 180 years to degrade, i.e., they cannot easily self-destruct, so they remain in the environment as solid waste for this long period of time, contaminating the environment, affecting the ingestion of animals and altering marine ecosystems (Aguirre *et al*., 2020).

However, the population does not take into account this fact that threatens the existence of human beings, animals and fish in the seas. Living conditions are continuously deteriorating in geographic and aquatic areas, endangering human, animal and fish health (Estrada *at al*., 2016), this calls for an awareness of the vulnerability of the environment of which humans, animals and fish are a part.

Figure 1. *Plastics in the home.*

Source: Photo by Bladimiro Centeno Herrera

The ingestion of microplastics

The derivatives of the excessive use of plastic bags are evident precisely in the deterioration of environmental conditions for the life of living beings. Microplastics have generated levels of contamination of the environment (Perdomo, 2002), el deterioro de la salud de los seres vivos (Estrada *et al*., 2016) y las alteraciones de los ecosistemas marítimos (Cáceres *et al*., 2019), lo cual se traduce en el progresivo deterioro los ecosistemas terrestres (Buteler, 2019), contaminación de las cadenas alimentarias (Andrades, 2013) y altera los ecosistemas marítimos en detrimentos de la flora y la fauna (Asalde, 2018).

Plastic waste mainly affects the oceans (Garcia, 2019), due to inadequate waste management, between 4.8 and 12.7 million tons of waste enter the seas each year. (Ruiz, 2019), including the distant and deep seas in which microplastics accumulate, a product of the indiscriminate manufacture of plastics for direct use, a precursor of other products such as synthetic fibers and other large plastics that become microplastics due to climatic effects that modify their physical properties. (Rios *et al*., 1981), they are decomposed and degraded by agents of heat, radiation, chemicals and mechanical energy (Posada, 1994) without being permanently eliminated.

These factors associated with plastic materials have a major impact on the entire planet (Castellón, 2010), cause collateral damage to human and animal food (Burgos & Michilena 2015). Plastic additives and monomers proved to be extremely hazardous to humans (Giraldez *et al*., 2020), as evidenced by the ingestion of terrestrial and aquatic animals. Likewise, population and economic growth and the lack of environmental awareness contribute to the expansion of these environmental problems, especially in the maritime environment (Torres *et al*., 2020), endangering marine organisms that suffer damage by ingestion and choking (Segura & Espin, 2015).

There is evidence of plastic waste ingestion in animals, especially in marine fauna such as whales, dolphins, turtles, fish and birds, in whose organisms traces of synthetic polymers such as ropes, bags, packaging and microplastics were found (Cáceres *et al*., 2015).

Table 2. Intake of plastics in animals.

Type of animal	Source of observation	Feeding area
Andean bear	Feces	Tamá National Natural Park - Colombia
Andean coati	Stomach contents	

Source: Authors' elaboration

Plastic residues have been found in the gastric contents of seabirds (Brandão *et al*., 2011), in marine debris from fishing (Denuncio *et al*., 2011) and has led to ontogenetic changes in feeding regimes (Torres *et al*., 2020). Obviously, this whole situation accumulates toxins and plastics in organisms (bioaccumulation), biomagnifying in other consumer species (INCYTU, 2019) and threatens the consumption of commercial fish species (Franck, 2015). Like marine animals, there are other terrestrial animals that mistake the plastic bag for food, block the digestive tract and generate inflammatory mucosal lesions such as stomatitis, gingivitis, conjunctivitis, pustular lesions, rhinitis (Castello *et al*., 2018).

Microplastics do not only affect marine organisms. Another concrete example is the ingestion of plastics by the spectacled bear, a terrestrial mammal, also called the Andean bear (Tremarctos ornatus), which has required a study of its food needs and preferences (Cáceres *et al*., 2015). They are exposed to the

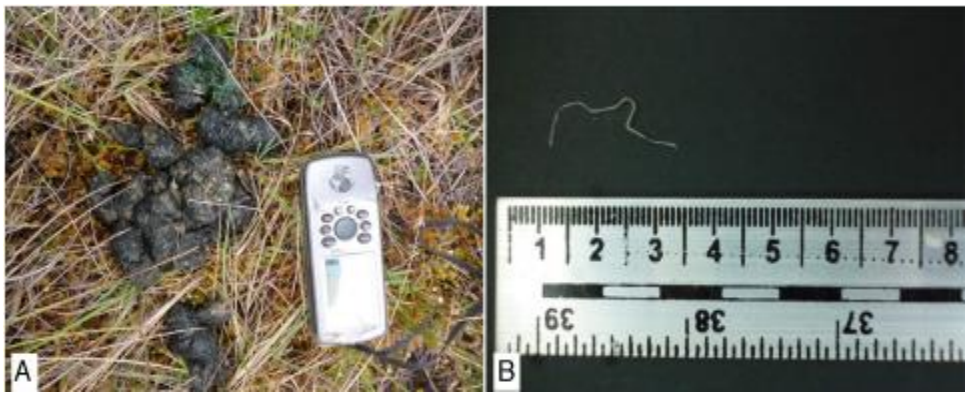

Figure 2. *A) T. ornatus feces with plant remains. Páramo de Santa Isabel, PNN Tamá, North of Santander, Colombia. B) Piece of plastic found in the feces of T. ornatus (Cáceres-Martínez et al., 2015)*

threat of microplastics including humans (Franck, 2015).

This ingestion of plastics causes symptoms of anemia, weight loss due to diarrhea and sudden death due to allotrophagy and haemonchosis in animals (Cardona *et al*., 2017), because it affects the energy balance, alters the amount of energy destined for growth, maintenance, reproduction and/or storage of reserve energy of the organism (Luhtakallio-Pérez, 2007).

One source for these intakes are the rivers that are used as dumps in large cities (Moreno-Huaranga *et al*., 2012), produce chemical elements that generate stomach dysfunctions (Rojo & Montoto, 2017). In the recycling processes of plastic materials, it has been possible to find highly dangerous toxic substances for operators (López & Lazzari, 2005). In this sense, there can be no doubt that plastic waste represents a danger to human, animal and fish life.

This panorama shows that the use of plastic bags is extremely harmful to the environment, health and the seas. Microplastics deepen the problem, require more effective technologies, specific environmental policies and specific social actions. To this extent, society must become more environmentally aware, academic entities must explore all technological possibilities for reducing plastic waste, and political authorities must assume a clear commitment against environmental pollution.

Recycling process

Faced with this situation, some policies aimed at the reuse of plastics have been implemented. Plastic recycling activities in educational institutions have been considered as mechanisms for environmental education, attitude changes, and ways to reduce the use of plastic bags (Nieva & Martínez, 2016); programs aimed at the reuse of solid waste have been evaluated based on the collection, sorting, transportation and sale of solid waste (Curcio et al., 2015).

The process of industrialization of solid waste has been another procedure proposed for the reduction of plastics through the intervention of private entities with the subsidy of state institutions within the framework of neoliberal policies (Demaria & D'Alisa, 2012), in other areas, participatory community activities have been developed to promote environmental care, solid waste management, recycling and the industrialization of plastics waste (Castillo & Moreno, 2013).

These antecedents force us to observe current public policies from the need for a comprehensive public management of garbage, taking into account the socioeconomic, physical, cultural and territorial specificities (Lam *et al.*, 2018), but these initiatives, on the one hand, evidenced a series of limitations in the supply chain for plastic recycling in business contexts that have failed to integrate the economic and environmental dimensions (Cespón *at al.*, 2015) and, on the other, they have not received the economic incentives necessary to sustain projects with these characteristics (Asalde, 2018).

Attitude changes

In this context, the most important challenge is how to generate a change of attitude in human beings (natural and legal) for the protection of the environment, where the paradox of coexistence between a high degree of concern in the individual and the incapacity for social change required for the development of pro-environmental behavior (Moreno et al., 2005), there is also no effective strategy for environmental education, which so far has relied on talks, workshops, conferences and the media, with experiential workshops being the most effective (Ccapa, 2019).

It is about bridging the gap between theory and practice for the transformation of attitudes and knowledge about environmental problems to develop behaviors consistent with sustainability (Álvarez & Vega, 2009), since it has been determined that there is a correlation between attitude and pro-environmental behavior (Herrera *et al.*, 2016), to that extent, global environmental education strategies should be developed.

Aware of the terrible threat to terrestrial and marine ecosystems that plastic waste represents in the environment, the largest global companies that produce plastics and other chemical compounds have signed an alliance in 2019 to end plastic waste ("Alliance to end Plastic Waste", AEPW). Multinational companies such as BASF, Dow, Procter & Gamble, among many others, are part of this alliance (Rios et al., 1981) which is an organization made up of the financial community, government, civil society, and various NGOs dedicated to environmental protection (Rios et al., 1981).

Solution alternatives

In this sense, a series of communication actions have been developed to make users aware of the need for effective management of plastic waste around the world, aimed at changing attitudes and comprehensive management of waste derived from plastics (Flores, 2020) and the development of behavior modeled by representative groups in a comparative way with groups habituated to the excessive use of plastic bags has been another effort to influence the change of attitude (Matos, 2013).

Various alternatives have been tested to replace the use of plastic bags, making cloth bags with local designs has been one of them. (Cáceres *et al.*, 2019), the use of residues generated by the harvest of bananas such as rachis, pseudostem and peel as raw material for the production of biodegradable plastic has been another (Haro et al., Bloisse, 2017), The use of plastic waste (Polyethylene Terephthalate) from disposable packaging and other waste for the manufacture of construction elements by incorporating crushed waste into the mix for the brick and tile factory complies with the slogan of the three Rs: reduce, reuse and recycle (V. Flores et al., 2014).

The use of microorganisms has also

been proposed for the production of polyhydroxyalkanoates (PHAs), which have characteristics similar to plastic with varied applications such as packaging, raw materials for hygiene products and biofuels, and thanks to their biocompatibility, they have great application in the medical field (Serrano, 2010); the use of natural (PHB, PHB-V) or synthetic (PCL, PLA, PGA) biodegradable polymers that suffer from the action of microorganisms is another alternative to reduce the impact of plastics (Martins & Marconato, 2006)

Regulatory proposals

In this context, the process of regulating the use of plastic bags is of vital importance (Asalde, 2018), a series of legislative initiatives have been presented that have resulted in rules regulating the production and distribution of plastic bags, through legislative initiatives that propose reforms and/or additions to the general laws for the prevention and integral management of waste in order to reduce the production and consumption of plastics (Legislatura, 2018).

Some national governments have undertaken a series of sanctions to curb the production, distribution and indiscriminate use of plastic bags; for example, in both Peru and Chile, fines have been imposed on small and medium-sized companies that do not comply with the prohibitive regulations, in Peru the tax is applied to users, requirements have been established for the production of biodegradable bags, and institutions have been established to monitor compliance with the actions (Rondon et al., 2021).

These references show that there is a need to deepen the content of the norms so that they regulate the production, distribution and reuse of plastic bags from a business perspective, establishing sanctions and specifying the necessary economic incentives for small and medium enterprises to incorporate these aspects as business assets that allow them to fight against environmental pollution in a corporate manner with other components of society. Establishing indicators that allow to rigorously measure the planned achievements or accomplishments (Incacutipa Limachi, 2021).

Table 3. Estimates on quantities and characteristics of the plastics

Quantities	Characteristics	Destination
380 million tons	Production of plastics	General use
300 million tons	Plastics waste	Environmental contamination
5-5 billion	Microplastics	Ecosystem impacts and ingestion in organisms
4.8/12.7 tons	Other plastics waste	Maritime coastlines

Source: Authors' elaboration

Conclusions

The problem of environmental pollution due to the use of plastic bags derives from the oil industry. Of 380 million tons of plastics produced annually, an average of 300 million tons are destined for the garbage and generate 5 and a half million microplastics that pollute the environment. Consequently, the technologies proposed for the substitution of plastics by other more biodegradable products are insufficient, the precarious environmental education requires a more effective pedagogical strategy and the legislative initiatives that, for the moment, are reduced to sanctioning postures, require the incorporation of criteria that encourage small and medium companies to reduce the production and use of plastics in the process of distribution of commercial products.

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