Characterization of microplastic pollution in marine fauna based on the impact on human health

Mark Alarco[1], Valeria Pacussich[2] , Ariet Salvatierra[3] , Héctor Vega[4]
Facultad de Ingeniería
Universidad Ricardo Palma
Lima, Surco 15039, PERÚ
201720047@urp.edu.pe, valeria.pacussich@urp.edu.pe,
ariet.salvatierra@urp.edu.pe, 201920924@urp.edu.pe

Mario Chauca
Grupo de Investigación en Ingeniería para la Ciencia y la Tecnología
(ERSTECH) Universidad Ricardo Palma
Lima, Surco 15039, PERÚ
mario.chauca@urp.edu.pe

Abstract

In the mid-70s, the massive use of plastic in industries began, which flows into rivers and lakes and finally ends up in the ocean. In the last 6 years, studies have been carried out and the presence of microplastics has been observed in different marine species, which then end up being part of our daily diet. The objective of this article is to raise awareness about the impact of microplastics on human health. Likewise, provide possible ideas to reduce the presence of microplastics in the sea. For the methodology to follow, a study carried out in 2018 by microplastics researcher Sherri Mason was taken into account, in which a luminescent dye was used that allows plastic microparticles to be visualized. It is known that, as a result of this study, several entities came out to question this research. In conclusion, this issue is very controversial since there are still no scientific techniques that demonstrate that microplastics are harmful to human health, but health experts and directors of various NGOs affirm that due importance should be given to the implementation of standards and laws that help regulate the use and destination of plastics.

Keywords
Plastic pollution, Plastic pollution, Microplastics, Plastic waste, Environment, Public health.

1. Introduction

According to the (Ministry of the Environment 2023), microplastics are small plastic particles, generally less than 5 millimeters, found in the environment, especially in oceans and freshwater bodies. Some of the characteristics of microplastics are that they are small plastic particles that can be difficult to detect with the naked eye; they are very resistant and do not break down easily, meaning they can persist in the environment for many years. Due to their size and the wide variety of sources from which they come, removing microplastics from the environment is a significant challenge. (Bollaín 2019) Microplastics can be ingested by marine organisms and accumulate in their tissues, which can have detrimental effects on the food chain. In doing so, they can travel long distances through water and air, meaning they can contaminate remote areas and affect wildlife around the world.

The presence of microplastics has been reported in some types of table salt, raising concerns for food safety and human health (Castañ***eda* 2020**). The presence of microplastics in table salt may be due to environmental pollution since seawater is used to produce salt, which may contain microplastics. Additionally, during the salt production process, ingredients containing microplastics may be added, such as food additives and packaging. Although it has been shown that ingesting microplastics does not pose an immediate risk to human health, continued exposure to these particles can have long-term negative effects. Therefore, measures must be taken to reduce the presence of microplastics in table salt and other foods.

Every time we throw a plastic bottle into the ocean, we contribute to the proliferation of microplastics that threaten marine life and, ultimately, our own health. (Sylvia Earle 2023) is an oceanographer and conservationist. The increase in the production and use of plastics around the world has caused an increase in the presence of microplastics in oceans, rivers, lakes, and soils. This problem has generated great concern in the scientific community and in society in general, since it is considered one of the main (Erik Solheim 2021) environmental challenges of our time.

Microplastics are like an invisible army that invades our oceans, soil, and air, generating unpredictable consequences for ecosystems and human health, former executive director of the (United Nations Environment Program UNEP 2023), Microplastics in table salt are a global problem that affects food safety and human health. It has been shown that microplastics can cause inflammation, oxidative stress, cell damage, and hormonal alterations in the human body. Additionally, microplastics can act as vectors for chemical contaminants, increasing the toxicity of food. Therefore, rules and regulations must be established to limit the amount of microplastics in food, and public awareness of the problem must be promoted. Also, more research should be done on the potential impact of microplastic exposure on human health, and epidemiological studies should be conducted to evaluate the risk associated with dietary intake of microplastics. Cooperation at the international level is essential to address the problem of microplastics in the food chain and ensure food security and human health.

Microplastics can also affect the economy indirectly through fishing, as well as other activities of great income to some countries, such as tourism, affecting people's health. Although it is true that there are no studies that certify these considerations, there are studies that demonstrate various health conditions from ingesting amounts of microplastics.

Figures from the latest studies (UN) estimate that 13 million tons of plastic are thrown into the sea every year, of which 90% are microplastics—a global environmental catastrophe that poses a threat to biodiversity. This the (United Nations Environment Program UNEP 2023), study alerts us to the amount of microplastics that could be present in living beings, despite the fact that laws have been put in place on the production and use of plastics.
Microplastics will not disappear on their own. They require our immediate attention and action to protect our ecosystems and ensure a sustainable future for future generations. (Criado A. 2018). As already mentioned, one way to try to mitigate this problem would be to consciously engage and develop a culture of how we intelligently dispose of plastics that are no longer used.

In 2017, Belgian scientists announced that seafood lovers could consume up to 11,000 plastic particles a year when eating mussels, a signature dish in that country. (Greenpeace 2019). Shellfish are of greater concern since they are consumed whole, including the stomach, which could contain microplastics.

In 2022, a team of CSIC scientists carried out a study that was published in Scientific Reports. In this study, it was stated that the ingestion of microplastics decreases the diversity of bacteria in the colon microbiota while causing an

imbalance in the microorganisms present. Given the possible chronic exposure to these particles through our diet, the results obtained suggest that their continued intake could alter intestinal balance and, therefore, health, says Victoria Moreno, researcher at the Food Sciences Research Institute (CIAL), in the press release issued by the CSIC. (Humberto J. Angrisano Silva 2021)

A pilot study shows that the feces of people from countries as distant and different as the United Kingdom, Italy, Russia, and Japan contained particles of polyvinyl chloride (PVC), polypropylene, polyethylene terephthalate (PET), and up to a dozen different plastics (Iberdrola 2023). Although this is a pilot study with a limited number of participants from various geographical locations and different types of plastics identified, the authors of the research emphasize the urgent need to evaluate the effects of these materials on human health.

Microplastics are found in various food products, such as salt, beer, fresh fruits and vegetables, and drinking water. The particles can become airborne and travel around the world in a matter of days before falling to earth as rain. Maritime expeditions to count microplastics in the oceans show incomprehensible quantities that have increased due to the increasing amount of plastic waste entering the oceans each year and breaking down. (Laureano Cornejo 2021)

According to the BBC, 250 bottles purchased in nine different countries were analyzed and found to contain an average of 10 plastic particles per liter, each larger than the width of a human hair, according to research led by the journalism organization Orb. Average tested at the State University of New York (USA) (Leonid Andronov 2021).
The most common plastics found by the researchers were polypropylene and polyethylene terephthalate (PET), the main components of plastic bottles and milk and juice containers. However, the researchers acknowledge that they cannot determine the exact origin of each particle and suggest that contamination of food with microplastics may occur during the different phases of food production or as a result of its packaging.

The number of countries implementing policies to reduce plastic consumption and address pollution problems continues to increase. The United Kingdom, United States, Canada, and New Zealand have banned the manufacture of personal care products containing microbeads. These tiny plastic particles are used in some beauty products for their exfoliating properties. During a single shower with a shower gel containing microbeads, it is estimated that up to 100,000 of these beads can go down the drain and end up in the ocean, where they are ingested by marine life, introducing potentially toxic substances into the food chain. (Martel I. 2020)

Wastewater is an important means of distributing microplastics. A high percentage of plastic particles found in wastewater, including clothing fibers, persist in sewage sludge, between 80% and 90%. Consequently, this sludge is often used as fertilizer, meaning that several thousand metric tons of microplastics can end up in our crops each year. It is possible to find these particles even in tap water. (Martí L. Ferrero P. and Verdejo, E. 2020) The researchers noted that it is not possible to determine the exact origin of each plastic particle, but they suggest that food contamination may occur during the different stages of production or as a consequence of packaging.

In 2020, the first field study evaluating the impact of microplastics on soil fauna was published in the journal Proceedings of the Royal Society. The study highlighted that microplastic contamination in the soil has affected the diversity of species that live below the surface, such as mites, larvae, and other small creatures essential for maintaining fertility.

Chlorinated plastic can release harmful chemicals into the soil that can leach into groundwater and other nearby water sources, which in turn can have negative effects on the species that drink that water. (Martí L. Ferrero,at all, 2020).

Studies have shown that more than 220 different species, under natural conditions, have ingested microplastics. Excluding birds, turtles, and mammals, 55% of these species are of commercial importance, including mussels, oysters, clams, brown shrimp, crayfish, anchovies, sardines, Atlantic herring, Atlantic starling, mackerel, cod, Atlantic cod, common carp, and yellow drum, among others. (National Geographic 2021) Until now, microplastics have only been found in small quantities in the intestines of certain organisms, and their impact on the population of these beings is not known with certainty. The information available on this matter is limited, but laboratory studies have shown that microplastics could be harmful to organisms.

Thousands of plastic containers and bags are thrown into the sea, even forming large surfaces or islands of plastic waste that progressively break down into particles due to various circumstances. Being an imminent threat that grows day by day as a work of man, we must take effective action. to mitigate this process. Furthermore, microplastics can also have negative economic and social repercussions, such as a decrease in the quality of fishery products and a reduction in tourism resources. Additionally, cleaning up and managing plastic waste, including microplastics, can be expensive and difficult to implement.

Microplastics can be found in a wide variety of places, including oceans, rivers, lakes, soil, sediments, the atmosphere, and even in consumer products such as bottled foods and beverages. (National Geographic 2022).
The production and use of plastics around the world has been increasing over the last 50 years. According to Greenpeace, production reached 380 million tons of plastic in 2015, and this figure is expected to increase in the future. (National Geographic 2022)

For this reason, efforts are being made to find ways to reduce the production and use of plastics and to develop technologies and strategies that mitigate the negative effects of microplastics. Some measures include banning microplastics in products such as cosmetics and cleaning products, promoting biodegradable and compostable alternatives, and improving waste management to prevent the release of microplastics into the environment.
Another important aspect to consider in relation to microplastics is their origin. Microplastics can be classified into two main categories: primary microplastics and secondary microplastics. (Sustainable development goals 2021) Primary microplastics are those particles that are released directly into the environment. A very important source is the washing of synthetic clothing, which contains 35% of these microplastics. Another is tire friction with the asphalt, which represents 28%. It is estimated that they represent between 15% and 31% of the microplastics present in the oceans. (Sustainable development goals 2021).

On the other hand, secondary microplastics are those generated by the degradation of larger plastic materials, such as bottles, bags, or fishing nets. They represent between 69% and 81% of the microplastics found in the oceans. (Sustainable development goals 2021).

Microplastics not only affect the ocean, but also water, air and land, 400 million tons of plastic are produced per year, only approximately 30% is recycled, which indicates the extremely critical level of pollution (World Health Organization 2019).

In summary, microplastics are a complex environmental problem that is of great concern to society in general. Further research and action are needed to reduce the production and use of plastics and find ways to mitigate the negative effects of microplastics on the environment and human health. Meanwhile, it is advisable to build a circular economy to forge a cleaner, healthier, and more sustainable future for all.

1.1 Objectives
The objective of this article is to raise awareness about the impact of microplastics on human health. Likewise, provide possible ideas to reduce the presence of microplastics in the sea.

2. Literature Review
We have taken into consideration the methodology of Dr. Mario Chauca to search for the best sources, taking recent information that is at least 5 years old, reliable from books, theses, and articles, and relevant and relevant from the best publishers, best universities, and best magazines, finally taking the better information for our sources.

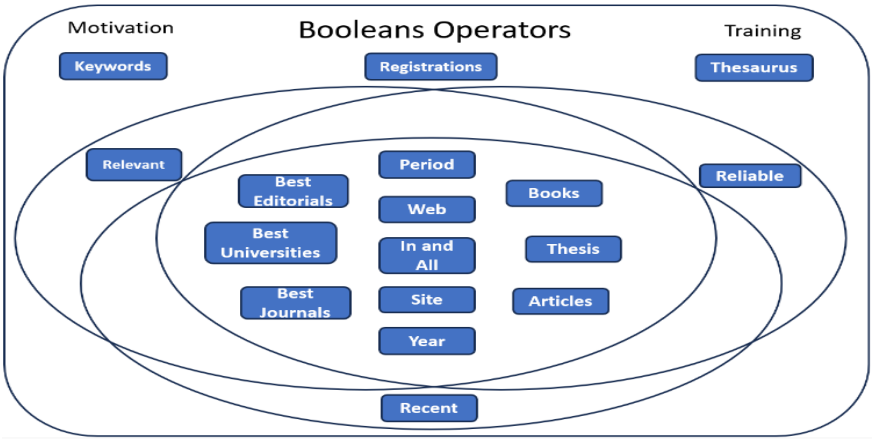


Figure 1. Search strategy by Dr. Mario Chauca

3. Methods

The division of primary and secondary microplastics stands out, where in the primary ones the main source is due to the introduction of plastic resin beads due to accidental loss of charge, and secondary microplastics come from the wear and tear of fishing gear and other equipment used, such as fishing trawl nets. background. (Pérez, Guillermo, 2023)

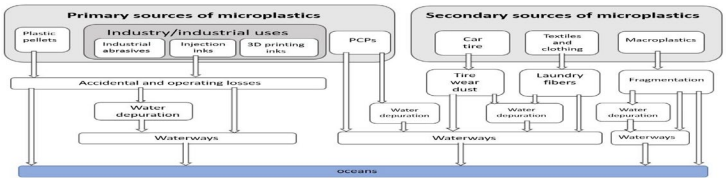


Figure 2. sources of microplastic on the oceans

Source: Microplastics and their interaction with antibiotics (Sánchez, I.). (United Nations Environment Program ,2021)

There are many chemical formulas used to make different types of plastics, each with its own specific properties and applications. Below are some common chemical formulas for widely used plastics.

Low-density polyethylene (LDPE): (C2H4) n

Figure 3. Polyethylene synthesis

Source: Plastics Technology.

High density polyethylene (HDPE): (C2H4) n

Polypropylene (PP): (C3H6) n

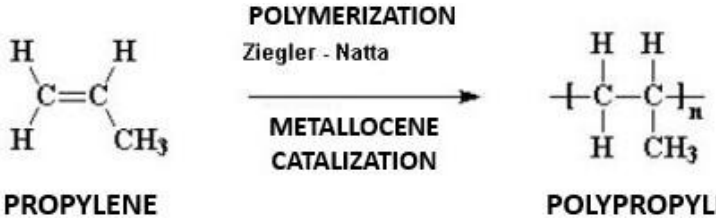


Figure 4. Molecular structure of propylene and polypropylene after polymerization Molecular structure of propylene and polypropylene after polymerization.

Source: LAUREANO CORNEJO, via new technologies and materials.

Poliestireno (PS): (C8H8) n

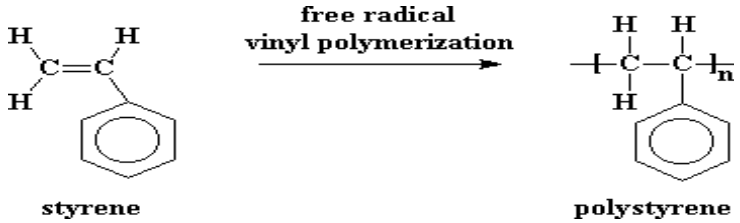


Figure 5. Structure of polystyrene foam Structure of polystyrene foam
Source: University of Southern Mississippi.

Cloruro de polivinilo (PVC): (C2H3Cl) n

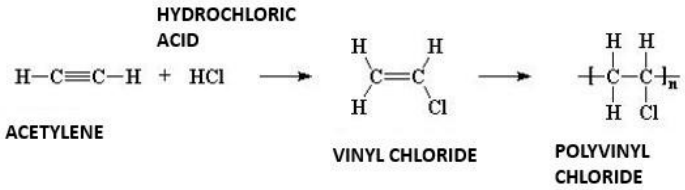
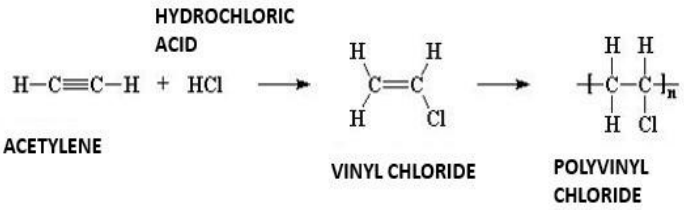


Figure 6. Polyvinyl chloride
Source: University of Southern Mississippi.



Tereftalato de polietileno (PET): (C10H8O4)

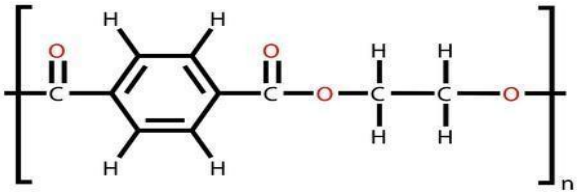


Figure 7. Fórmula estructural del polietileno tereftalato.
Source: Leonid Andronov, via Shutter Stock Photo.
Polymethyl methacrylate (PMMA): (C5O2H8) n

Figure **8**. Equation for the polymerization of methyl methacrylate into 7-linden polymethacrylate.
Source: Cjp 24, CC0, via Wikimedia Commons.

Polyurethane (PU), which varies depending on the formulation, generally contains isocyanates and polyols. It is important to note that these formulas represent the repetition units of polymers, and the letter n indicates that the polymer chain can contain a variable number of repetitions.

The most widely used method in the production of plastic bottles is blow molding. This process consists of taking advantage of air pressure to expand the initial plastic shapes in the cavity of a mold, which results in the

manufacture of bottles and other plastic containers with extremely thin walls. Blow molding is carried out in two stages (Rtve, 2019)

1. Preparation of the tube from the preform (molten plastic): PET reaches the industry in the form of small pieces or granules, which are melted and injected into a mold. This mold is used to obtain the preform, which resembles a test tube and already has the neck opening and the airtight seal at the bottom.
2. Injection of pressurized air into the tube so that it acquires the desired shape: The purchased proforma is heated in an oven to an average temperature of 100 °C. This procedure aims to soften it and make it more flexible, then it is stretched and blown in a mold until it gives it its final shape. Once blown, the bottle must be cooled immediately to maintain its shape.

It is also known that there are several techniques to carry out the blow molding process:

- ✓ Extrusion: blow molding: the selected plastic is melted and molded to obtain a tube or make. During molding, the lower end of the tube is sealed. Pressurized air is then injected into the preform to give it the desired shape. Finally, the bottle is cooled to make it easier to remove.
- ✓ Injection and blow molding: This technique merges injection molding and blow molding into a combined process. Once the plastic is melted, it is injection molded around a core to obtain the preform. The preform is then placed in a mold, and pressurized air is injected into it to give it its final shape. Once this stage is completed, the piece is allowed to cool and is ejected from the mold.
- ✓ Coextrusion (blow molding): This technique is used in the manufacture of bottles or multilayer containers. The process begins with the injection of the preform, which is heated using infrared heaters. Subsequently, air is injected at very high pressure while a rod stretches it, allowing it to expand and acquire its final shape.

The production of PET bottles is briefly described below.

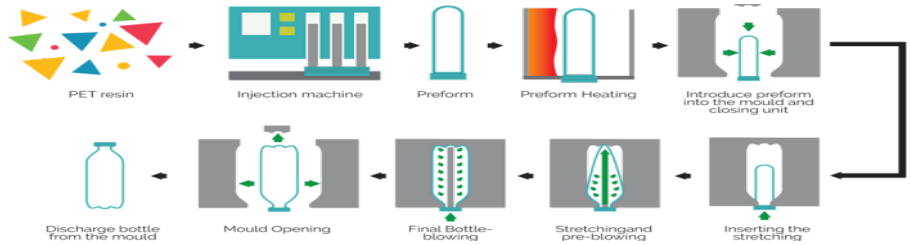


Figure 9. PET bottle manufacturing process.

Source: IQR - Chemical Engineering**.**

Now that we have a general idea of how bottles are manufactured, we move on to present a flow chart showing the complete PET bottle production process, including the material recovery phase.

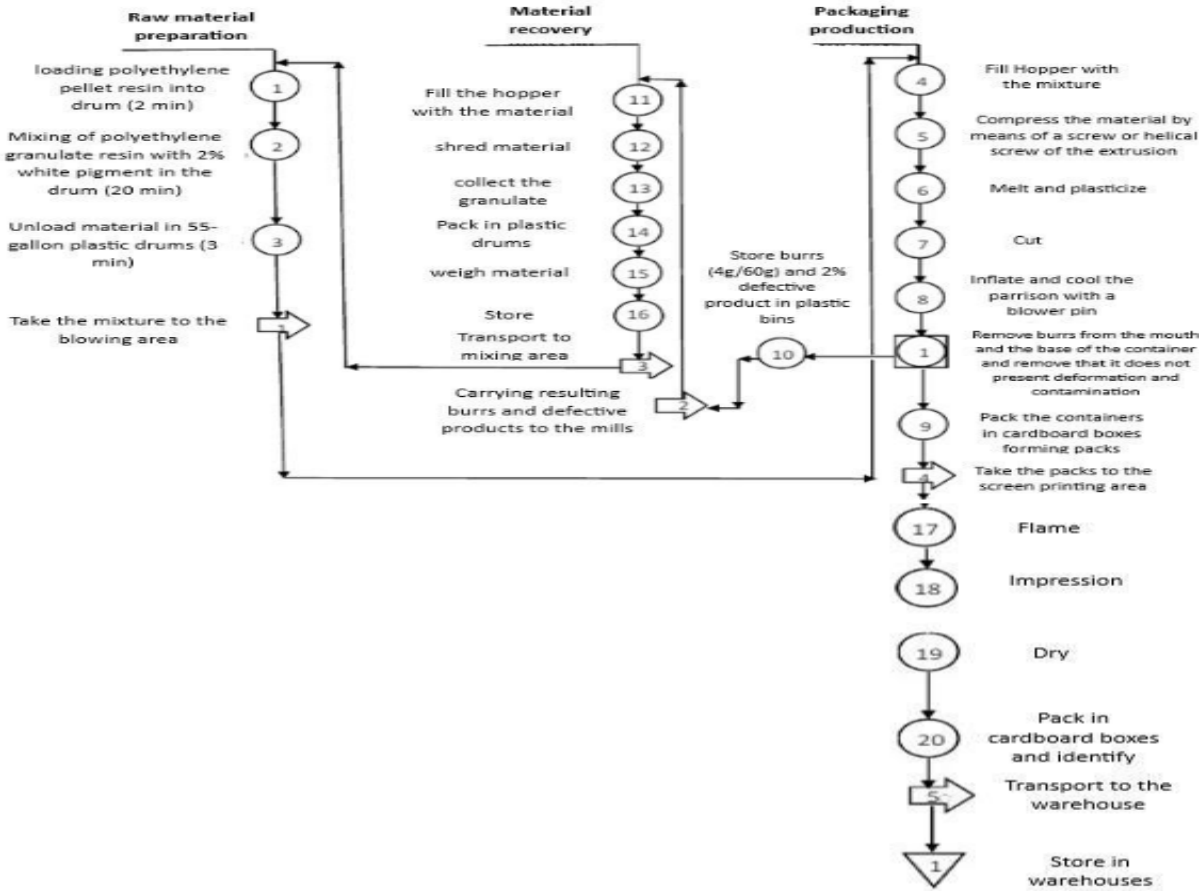


Figure 10. Flow chart of the PET bottle manufacturing process.
Source: IQR - Chemical Engineering**.**

Below is a graph with global plastic production:

Figure 11. World production of plastics.
Source: Microplastics and their interaction with antibiotics (Sánchez, I.)**.**

Another promising approach is the use of specific enzymes and microorganisms capable of breaking down plastics into simpler and more biodegradable components. By applying these biological agents in suitable environments, it

may be possible to degrade plastics and reduce the amount of microplastics present in the environment. (United Nations Environment Program, 2021)

Microplastics are a constant reminder of our dysfunctional relationship with plastic. We must seek innovative solutions and reduce our dependence on this material to preserve our planet (Sylvia Earle, 2023).
Dr. Maria Neira, Director of the WHO Department of Public Health, Environment, and Social Determinants of Health, explains: We urgently need more data on the health effects of microplastics, which are present everywhere, including in our drinking water. The limited information available seems to indicate that drinking water contaminated by these materials is not harmful to health, at least at current levels. However, we must continue studying this issue to prevent plastic pollution from continuing to increase around the world. (National Geographic, 2023)

Microplastics have been associated with neurotoxic effects in wild fish and increased oxidative damage, which could initially lead to an increased risk of developing cancer. On the other hand, there are studies that affirm that these materials do not have permanent effects on fish and only harm them when they pass through their digestive tract. (National Geographic, 2022).

Participating in beach and river cleanups is an effective way to reduce the amount of plastic in the environment. It can be done in a group or individually. Therefore, we humans are solely responsible for taking steps to stop this problem. Only with the joint action of all can we stop the pollution of the planet and its devastating effects on the environment. (Sustainable development goals, 2023).

However, in 2018, in the month of March, the results of a study were published in different media. Plastic was found in 93% of bottled water samples from brands such as Evian, Aqua, Aquafina, Dasani, Nestlé Pure Life, and San Pellegrino. (Pérez, Guillermo, 2023)

The 2018 study by microplastics researcher Sherri Mason, a professor at the State University of New York at Fredonia, notes that they reviewed the water from more than 250 bottles from nine countries (Brazil, Mexico, China, the United States, India, Indonesia, Kenya, Lebanon, and Thailand) and found particles of polypropylene, nylon, and polyethylene terephthalate (PET), used to make bottle caps, among the remains. (World Health Organization, 2019)

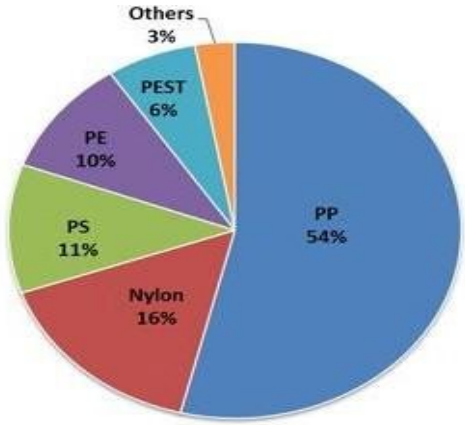


Figure 12 > 100 um

Source: Ly Company – Aquaiy, contamination by synthetic polymers in bottled water.

On average, the researchers found 10.4 particles of about 0.10 millimeters in one-liter water bottles. "I think they come from the bottling processes, and I think most of it comes from the bottle itself, its cap, and the industrial bottling process," Mason told AFP. (World Health Organization, 2019).

The study was carried out for three months with a technique developed by the Faculty of Chemistry at the University of East Anglia (UEA), in England, that allows plastic microparticles to be visualized using a luminescent dye. Andrew Mayes, a scientist at the UEA Faculty of Chemistry, points out that the results are consistent. (World Health Organization, 2019)

5. Results

Since the term microplastic began to be used, the number of related publications has increased, as can be seen in the following graph. This is a clear indicator of the acceptance of the term by the scientific community and the exponential increase in the number of works published on the subject.

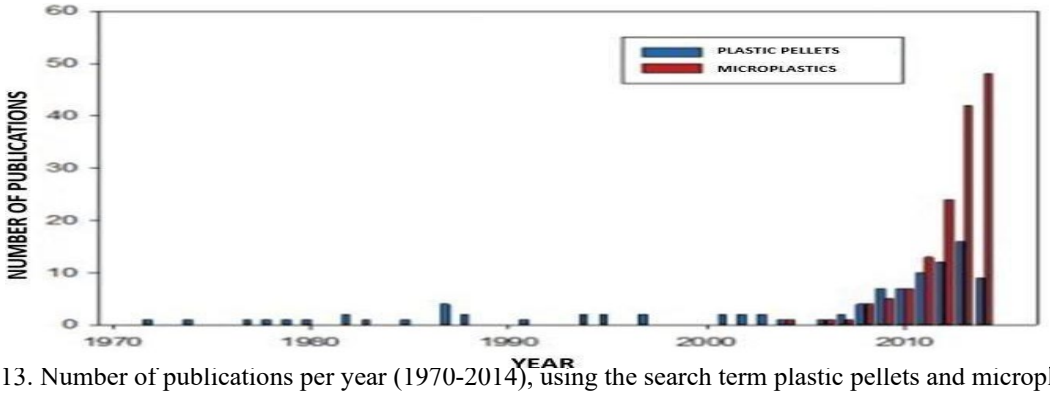


Figure 13. Number of publications per year (1970-2014), using the search term plastic pellets and microplastics
Source: Presence of microplastics in water and its possible impact on public health**.**

There are several classifications of the different types of plastics, based on their sizes and sources of origin, including.

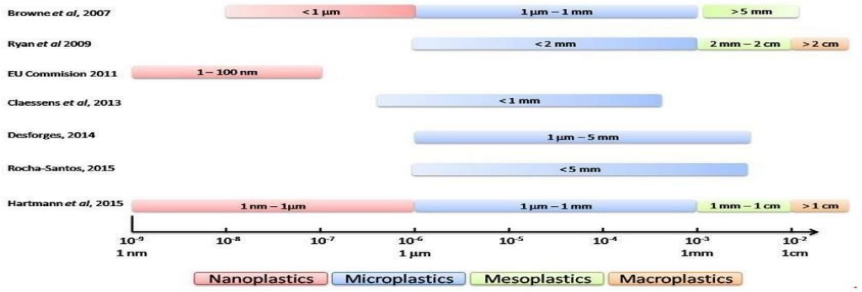


Figure 14. Diferentes tipos de plásticos según su tamaño y procedencia.
Fuente: Da costa et al, 2016.

Macroplastics: macroplastics, also known as floating plastics in the open sea, are usually present in the form of macropieces from recreational items (glasses, bottles, plates, balloons, toys, etc.) that are dumped in various coastal areas.

Over time, larger plastic waste breaks down into macroplastics. Due to their low density and mobility, these macroplastics are easily transported through the terrestrial environment and reach various aquatic ecosystems.
Microplastics: the term microplastics appeared for the first time, identifying those with a size between 5 mm and 100 nm, which usually appear as granular and fibrous plastic fragments with a dimension of around 20 µm. Within microplastics, two subcategories were distinguished: small microplastics (<1 mm) and large microplastics (between 1 and 5 mm). (Tamapack 2022)

It is important to note that the toxicity associated with microplastics depends mainly on the dose and factors related to the polymers, such as type, particle size, surface chemistry, and hydrophobicity. The accumulation rate of microplastics in different human tissues and their distribution in them are directly related to the size of the particles (Pérez Guillermo 2023).

Nanoplastics are those with a size between 1 nm and 100 nm. (TecnoXplora 2018). Adequately detecting and quantifying their presence in the environment is a challenge due to the technical difficulties in isolating and measuring them. However, they are released into the environment as a result of the degradation of larger plastic

fragments, making them a considerable threat to both the environment and human health. Every time we breathe, drink water, or eat food contaminated with microplastics; we are participating in a massive, unintended experiment that could have serious consequences for our health. (Tyree C. and Morrison D. 2018)
As for the results of the study, they were compared with a previous study carried out in 2017 by Orb Media, in which they had shown that plastic particles were also present in tap water, although in smaller quantities. (Pérez Guillermo 2023)

Likewise, Scott Belcher, professor of toxicology at North Carolina State University, points out that if you have contaminated and unsafe water, bottled water may be your only alternative. (Velarde L. 2021). This implies that bottled water should not be our first choice. Mason also states that tap water, in general, is much safer than bottled water. (Pérez Guillermo 2023).

It is known that the French National Federation of Packaged and Bottled Waters (FNECE) assured in a statement that the water produced and sold in France was of the highest quality. In addition, the organization stressed that there was neither an official methodology to analyze microplastics nor a scientific consensus. (Pérez Guillermo 2023). The federation implies that microplastics are present throughout the environment, which could have altered the results of the analyses if an extremely rigorous protocol had not been followed. Furthermore, the International Bottled Water Association considered that this study is not supported by reliable science and has not been peer-reviewed, as is common in scientific publications (Pérez Guillermo 2023). Faced with this situation, the WHO has expressed its concern and said that it will open an investigation to determine the negative consequences of consuming bottled water. However, representatives of the brands involved have not taken it too seriously, since the extent of the risks posed by these particles to human health is unknown.

5. Discussion

Microplastics has been the subject of many discussions and debates around the world due to their negative environmental impact. Below are some of the most important debates related to microplastics:

- Impact on human health: Humans can ingest microplastics through contaminated seafood and drinking water, which has raised concerns about potential effects on human health. Although the long-term effects of exposure to microplastics are still uncertain, there is evidence to suggest that they can have toxic effects and cause inflammation and other health problems.

- Disposal difficulties: Microplastics are very persistent in the environment and are difficult to eliminate. This has raised concerns about long-term environmental damage and prompted the development of solutions for the removal and prevention of microplastics. Need for coordinated action: Since microplastics are a global problem, internationally coordinated action is required to address the problem effectively. This includes cooperation between governments, industry, scientists, and society at large to develop sustainable and effective solutions.

6. Conclusion

- The presence and effects of microplastics in aquatic environments are an emerging problem with implications for public health. Its study is much more advanced in the marine environment, and only in the last 6 years has it begun to be evaluated in continental waters and those intended for human consumption.
- The measures focus on reducing the initial creation of microplastics by regulating their inclusion in other products. However, the main complication lies in the management of microplastics caused by the degradation of existing plastics in water. Therefore, regulations that restrict the use of single-use plastics are already being implemented to address this problem.
- The presence of microplastics in water supplies, drinking water, and bottled water has been the subject of several published studies with conflicting results. A problem that limits the clarity of the information obtained is the lack of coordination in the definition and description of microplastics, as well as the difficulty of establishing standardized analysis methods that allow the results to be accurately compared.
- It is essential to give more importance to further research into the possible effects and presence of microplastics in the food chain and in drinking water, due to the lack of scientific evidence currently available. Until more data is obtained, and effective means of control are established, it is unlikely that microplastics can be considered a control parameter in water intended for human consumption.
- Health experts agree that more research is needed to confirm whether the levels of plastic in bottled water are harmful to our health.

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Biographies

Hector Vega (08/03/2001), a student in the 9th cycle of industrial engineering at the Faculty of Engineering at the Ricardo Palma University, I am in the upper fifth and my area of interest is Lean Manufacturing, sustainability, automation in engineering and others.

Mark Alarco (28/081999), a student in the 9th cycle of industrial engineering at the Faculty of Engineering at the Ricardo Palma University, I am in the upper fifth and my area of interest is Lean Manufacturing, sustainability, automation in engineering and others.

Valeria Pacussic (29/11/2001), a student in the 9th cycle of industrial engineering at the Faculty of Engineering at the Ricardo Palma University, I am in the upper fifth and my area of interest is Lean Manufacturing, sustainability, automation in engineering and others.

Ariet Salvatierra (08/09/2000), a student in the 9th cycle of industrial engineering at the Faculty of Engineering at the Ricardo Palma University, I am in the upper fifth and my area of interest is Lean Manufacturing, sustainability, automation in engineering and others.

Mario Chauca (30/11/1966), a professor at Ricardo Palma University, He is an electronic engineer with doctorate in Education and master's in administration with mention in Business Management. He is Vice-president IFEES 2021-2023, Executive Committee Member, Fellow at IEOM Academy International Society. IEOM Global Award Engineering Education. Served as Committee Award Duncan and Award Fraser at IFEES global.