WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

SJIF Impact Factor: 5.464

ISSN: 2457-0400
Volume: 7.
Issue: 8
Page N. 85-95
Year: 2023

Review Article www.wjahr.com

# MICROPLASTICS IN THE WATER. A GROWING PROBLEM THAT REQUIRES ATTENTION

**Alicia Armentia*[1,2], María San Miguel[1], Angel San Miguel[3], Sara Martín[4], Blanca Martín[1], Julia San Miguel[1], Manuel Gonzalez-Sagrado[1]**

[1]Research Unit. Rio Hortega Valladolid University Hospital. Spain.
[2]Allergy Service, Rio Hortega Valladolid University Hospital. Valladolid University. Spain.
[3]Clinical Analysis Service. Hortega Valladolid River. University Hospital. International University of La Rioja (UNIR). Spain.
[4]Department of Pediatrics, Virgen de la Concha Hospital, Zamora, Spain.

**Received date:** 03 June 2023 **Revised date:** 23 June 2023 **Accepted date:** 13 July 2023

***Corresponding Author: Alicia Armentia**
Research Unit. Rio Hortega Valladolid University Hospital. Spain.

## SUMMARY

Microplastics are tiny plastic particles found in bodies of water, and their presence represents an increasingly important environmental and public health problem. These microplastics can have a variety of sources, including fragmentation from larger plastics, wear and tear from synthetic products, and direct release from cosmetic and personal care products. These microplastics enter water bodies through different routes, such as sewage systems, surface runoff, and atmospheric deposition. Once in the water, they have a significant impact on aquatic organisms. They can be ingested by a wide variety of species, from microorganisms to fish, seabirds, and marine mammals. They can accumulate in the tissues of these organisms and cause physical damage, such as intestinal obstructions and reduced feeding capacity. Additionally, microplastics can act as vectors for toxic chemicals, as they can adsorb and transport contaminants present in water, posing additional risks to aquatic life. As for the effects on human health, although more research is still needed, there are concerns about the possible negative impacts of microplastics. Ingestion through food, especially contaminated shellfish, raises the possibility of transfer of plastic particles and associated chemicals to humans. It has been suggested that microplastics can cause inflammation and damage in the gastrointestinal tract, as well as the release of toxic chemicals into the human body. In addition, there is also the potential for respiratory exposure through inhalation of airborne microplastics. To address this problem, concrete actions are required. It is essential to reduce the consumption of single-use plastics and improve waste management to prevent microplastics from reaching bodies of water. The implementation of advanced technologies in wastewater treatment plants is also necessary to effectively capture and remove microplastics. In addition, continued research, public education, and international cooperation are needed to increase awareness of the problem and develop effective mitigation strategies. Microplastics in water represent a threat to aquatic ecosystems and human health. To protect our ecosystems and our health, it is crucial to take measures to reduce pollution by them, improve waste management and promote sustainable practices in the consumption of plastics.

**KEYWORDS:** Microplastics, water, health.

## INTRODUCTION

Microplastics are plastic particles that are less than 5 millimeters in size and have become an environmental problem of great concern throughout the world. These tiny particles are found in a variety of sources and have contaminated aquatic ecosystems, including rivers, lakes, and oceans. In this article, we will explore the presence of microplastics in water, their impact on aquatic organisms, and the efforts needed to address this growing problem.[1-12]

In figure 1, different fragments of plastic products can be seen in a water bottle.

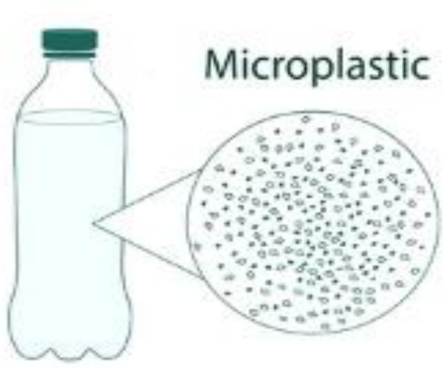


**Figure 1: Fragments of isolated plastic products in water.**

Microplastics have emerged as a major environmental concern in recent decades. These tiny particles, measuring less than 5 millimeters in diameter, are widely distributed in bodies of water around the world, from rivers and lakes to oceans. As awareness of microplastics has grown, concern about their harmful effects on aquatic ecosystems and human health has also grown.[13-19]

They originate from different sources and come in various forms. Some are generated through the fragmentation of larger plastics that have been discarded in the environment. These can come from bottles, containers, bags and other plastic products of common consumption. Other microplastics are the result of the breakdown of synthetic fibers present in clothing, released during machine washing, and subsequently transported to water systems through wastewater.[20-25]

In addition to these direct sources, they can also be introduced into the environment through indirect sources. Thus, many personal care products, such as facial and body scrubs, contain plastic microbeads that wash down the drain and end up in bodies of water. Likewise, atmospheric deposition also plays an important role in dispersion, since airborne particles can be deposited on aquatic surfaces through rain or snow.[26-29]

Once in the water, they disperse and become ubiquitous. Their minute size and buoyancy allow them to be carried by currents and widely distributed in aquatic systems. As they are ingested by aquatic organisms, they can accumulate in the food chain, from the smallest organisms to fish and marine mammals. This pollution poses serious threats to aquatic life, altering the biological processes, reproduction, feeding and health of marine organisms.

In addition to the impacts on aquatic ecosystems, increasing attention is also being paid to the potential effects of microplastics on human health. Although more research is still needed to fully understand the risks, evidence has been found that they can enter the human food chain through the consumption of shellfish and contaminated drinking water. This raises concerns about possible adverse health effects, such as the transfer of toxic chemicals and inflammation in the gastrointestinal tract.[10,30-33]

Microplastics in water represent a complex and constantly evolving environmental challenge. The widespread presence of these tiny particles in bodies of water and their impact on aquatic ecosystems and human health underscore the need to urgently address this problem. By understanding the sources of pollution, the effects on aquatic organisms, and mitigation efforts, we can work toward sustainable solutions that protect our water resources and promote a cleaner, healthier future.[7,9,13,18]

Figure 2 schematically shows the transport of microplastics through the seas.

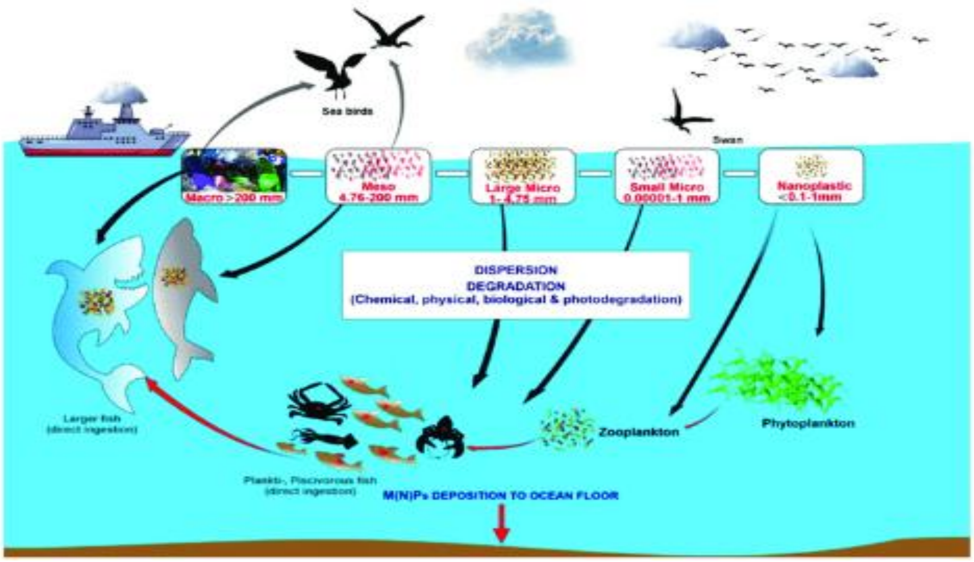


**Figure 2: Graphic representation of the transport of microplastics through the seas.**

### Types of Microplastics

Depending on their origin, there are[3,5,7]

**Primaries microplastics.** They are the microscopic plastic particles or fibers created by man. in order to serve as exfoliants, abrasives, binders or as microcomponents of other products, which end up being discarded directly into the environment.

They find each other mostly in the form of granules (microspheres) so once they are used, they go down the drain and due to their small size, they are lost between the filters and are not treated in the treatment plants, like the particles that are in the exfoliating gels and toothpastes.

Another very important source of microplastics is the cosmetic industry and the fashion industry.

Microplastics in the fashion industry, since the synthetic laundry washing unload between half and one million tons annual release of plastic microfibers in wastewater.

Fibers derived from petroleum include, polyester, nylon, acrylic, polypropylene and elastane.

It is estimated that between 15% and 31% of microplastics in the ocean are of primary origin.

Secondary microplastics. They originate from the degradation of larger plastics, such as bags, bottles or fishing nets. They come to represent between 70-81% of microplastics in the ocean**.**

### Sources and Routes of Microplastics Contamination

Microplastics can have different sources and follow different routes of contamination before reaching water bodies. It is important to understand these sources and routes to effectively address the problem of these in the water. The main sources and routes of contamination are[34-37]

**Fragmentation of larger plastics.** One of the most significant sources of microplastics is the fragmentation of larger plastic objects that have been discarded in the environment. Plastics, such as bottles, containers, and bags, can break down due to exposure to sunlight, mechanical wave action, and erosion. This results in the generation of smaller fragments, including nano and microplastics.

**Synthetic clothing fibers.** Another major contributor to water is the synthetic fibers present in clothing. During the washing of garments made of materials such as polyester, nylon and acrylic, small plastic particles in the form of fibers are released and enter the water system through wastewater. These fibers can be transported to rivers, lakes and oceans.

**Personal care products.** Many personal care products, such as facial scrubs, shower gels, and toothpastes, contain plastic microbeads. These microbeads are solid plastic particles that are used for exfoliating or decorative functions. When used and rinsed away, microbeads can end up in sewage systems and eventually make their way into bodies of water, contributing to microplastic pollution.

**Atmospheric deposition.** Microplastics can also enter water through atmospheric deposition. Airborne plastic particles, such as fine dust or larger plastic fragments, can be deposited into bodies of water through rain or snow. These particles can come from various sources, such as the degradation of plastics in the atmosphere or the release of particles during industrial processes.

Once they reach the water, they can follow different routes of contamination. Surface runoff is a common pathway, where they are present on soils and paved surfaces and are washed away by rainwater into rivers and lakes. Sewer systems also play an important role, as microplastics released through domestic and industrial wastewater can be transported to wastewater treatment plants or directly into water bodies without proper treatment.

In addition, ocean currents can transport microplastics over long distances, dispersing them in remote areas and even affecting marine ecosystems far from pollution sources.[38,39]

Therefore, they can have multiple sources and follow various routes of contamination before reaching water bodies. The fragmentation of larger plastics, synthetic fibers from clothing, personal care products, and atmospheric deposition are key sources of microplastics in water. Surface runoff, sewage systems, and ocean currents are some of the routes that microplastics can follow to enter aquatic ecosystems. It is essential to address these sources and routes of contamination to mitigate their presence in water and protect our valuable water resources.[5,7,19]

Figure 3 shows the transformation of microplastics in the different water columns.

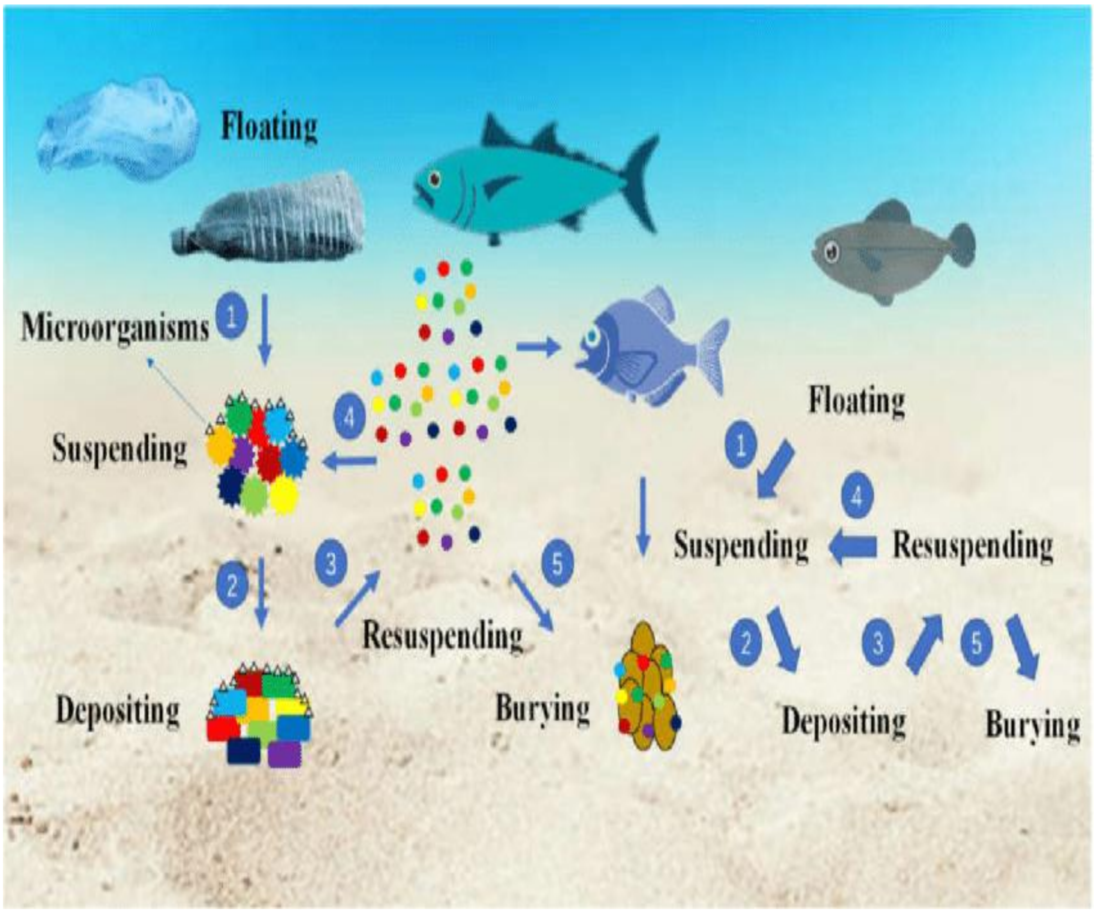


**Figure 3: Transformation of microplastics in the different water columns.**

**Impact on Aquatic Organisms**

The presence of microplastics in water has a significant impact on aquatic organisms, from the smallest microorganisms to fish, seabirds and marine mammals.

They have a detrimental impact on aquatic organisms at different levels of the food chain. From zooplankton to fish, seabirds and marine mammals. They can affect the feeding, growth, reproduction and general health of these organisms. In addition, they act as vectors of chemical contaminants, exacerbating the risks for aquatic organisms and ecosystems as a whole. It is essential to take measures to reduce the presence of microplastics in water and protect aquatic life and aquatic ecosystems in general.

The impact on these organisms affect[4,10,17,22]

**- Zooplankton and filter feeders.** Zooplankton, like copepods and krill, play a fundamental role in aquatic ecosystems as the base of the food chain. Microplastics can be ingested by these organisms while feeding, which can have negative effects on their ability to feed, grow, and reproduce. Also, their presence can clog their filtering organs, hindering their ability to capture food and affecting their general health.

**- Fish and larger aquatic life.** Fish can ingest microplastics directly or through their diet by consuming contaminated organisms. This can cause physical damage to their internal organs, such as the digestive tract, and affect their ability to properly digest and absorb nutrients. In addition, they can also accumulate in the tissues of fish, which can have consequences as they move through the food chain and are eaten by larger predators.

**- Sea birds and marine mammals.** Seabirds and marine mammals, such as sea turtles, seals, and whales, are also affected by microplastics in the water. These animals can ingest microplastics by mistaking them for food or by feeding on prey that contains plastic particles. And they can cause obstruction of the digestive tract, which can lead to starvation, and can also release toxic chemicals that affect the health and reproduction of these animals.

Figure 4 graphically represents the main migration routes of microplastics in the aquatic environment.

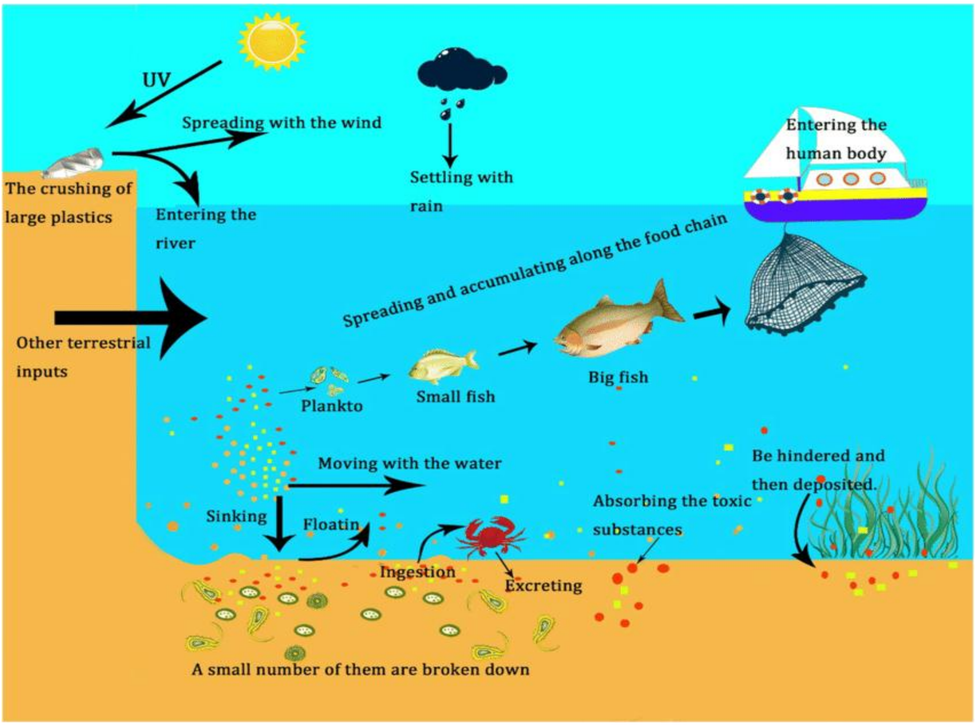


**Figure 4: Main migration routes of microplastics in the aquatic environment.**

In addition to direct effects on aquatic organisms, they can also act as vectors for chemical contaminants. Some chemicals present in water can adhere to the surface of microplastics, such as pesticides, heavy metals, and endocrine disrupting chemicals. When aquatic organisms ingest contaminated microplastics, they may also be exposed to these toxic substances, which can have negative effects on their health and on ecosystems as a whole.

Figure 5 graphically describes the contamination by microplastics at different levels. Thus they enter the food chain and later in the different populations of organisms and later at the different cellular and subcellular levels in the organisms, which can also interact with the DNA of the organisms to alter gene expression and their physiology.

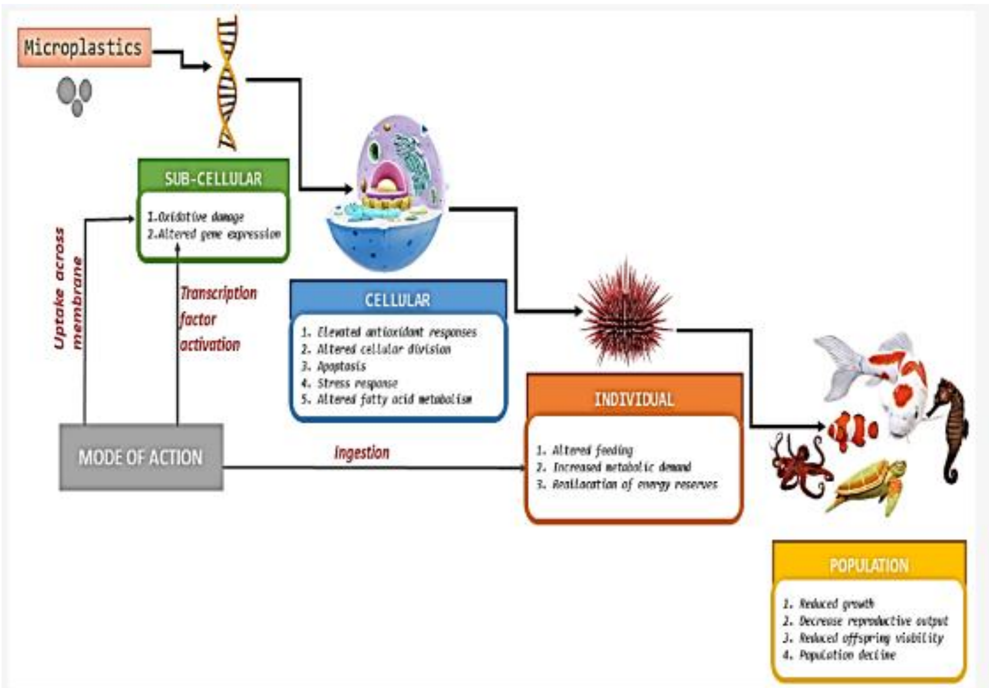


**Figure 5: Contamination by microplastics at different levels. Thus, they enter the food chain and subsequently the population. Then they reach cellular and subcellular levels in different organisms, in addition to humans.**

**Effects on Human Health**

While research on the effects of microplastics on human health is ongoing, concerns have been raised about potential negative impacts. Although more studies are still needed to fully understand the risks, some potential human health effects related to microplastics in water have been identified.

The main effects produced are[6,22,24,27,31]

- **Ingestion through the food chain.** Microplastics present in bodies of water can be ingested by aquatic organisms, such as shellfish, which are an important part of the human food chain. If humans consume shellfish contaminated with microplastics, there is a chance that the plastic particles will also be ingested by people. Although the magnitude of the transfer of microplastics in the food chain and its impact on human health is still being investigated, it is an area of growing concern.

- **Release of chemical substances.** Microplastics can contain or adsorb toxic chemicals present in water, such as pesticides, polycyclic aromatic hydrocarbons (PAHs), and endocrine disrupting chemicals. When ingested by humans, there is a potential for these chemicals to be released in the gastrointestinal tract and absorbed by the body. This raises concerns about possible adverse health effects, such as toxicity and interference with the endocrine system.

- **Gastrointestinal inflammation and damage.** It has been suggested that the presence of microplastics in the gastrointestinal tract can trigger inflammatory responses and cause damage to the lining of the digestive tract. These effects could be related to the size, shape, and chemical composition of the microplastics. However, more research is needed to fully understand the precise mechanisms and effects in the human gastrointestinal system.

- **Exposure via the respiratory route.** In addition to ingestion through food, there is also the possibility of exposure to microplastics via the respiratory route. Airborne plastic particles, including microplastics, can be inhaled and deposited in the lungs. Although the extent and effects of this exposure are still unknown, it raises concerns about possible impacts on lung and respiratory health.

It is important to note that research on the effects of microplastics on human health is still ongoing, and further studies are needed to properly assess the risks and understand the mechanisms of action. In addition, your exposure can vary depending on factors such as geography, drinking practices, and water quality.[36-38]

Much research is being done on the effects on human health, the presence of them in water raises concerns about the ingestion of plastic particles and the possible release of toxic chemicals. In addition, numerous concerns are raised about inflammation and gastrointestinal damage, as well as possible exposure via the respiratory route. Further research is critical to fully understand the risks and take appropriate measures to minimize exposure to microplastics and protect human health.

In figure 6, the different routes of human exposure and the effect of micro and nanoplastics are represented.

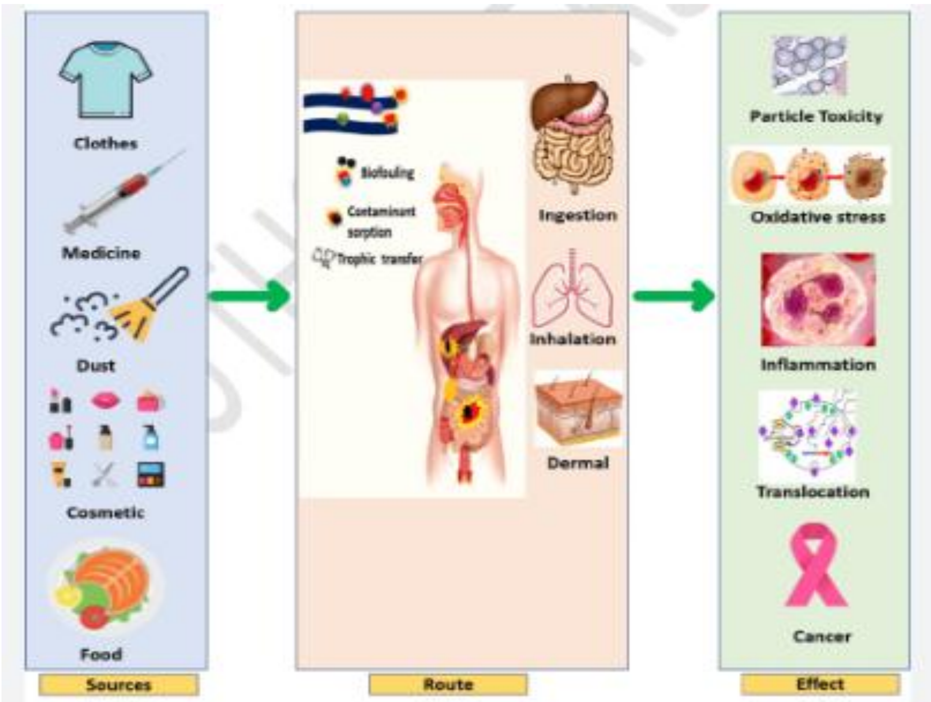


**Figure 6: Different routes of human exposure and the effect of micro and nanoplastics.**

Figure 7 shows a general representation of the environmental fate of the different microplastics.

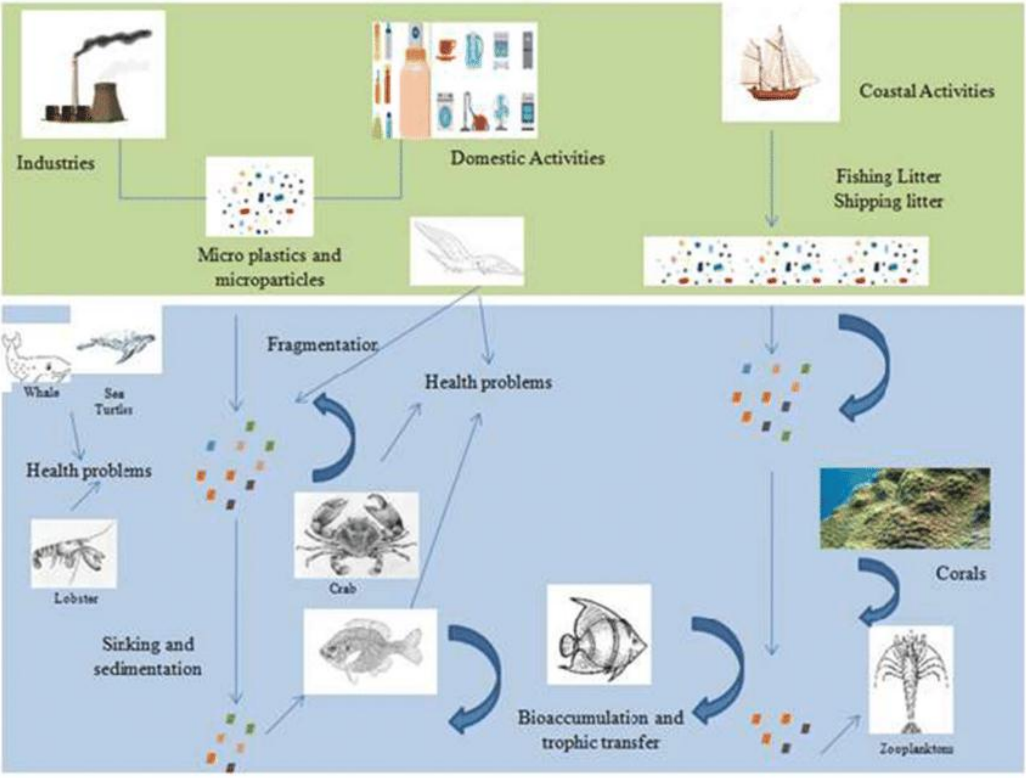


**Figure 7: A general representation of the environmental fate of microplastics.**

**Necessary Actions**

The impact of microplastics on water, air and human health requires the implementation of concrete actions to address this growing problem. Some of the necessary actions will include[22.27,31,37]

**-Reduction of single-use plastics.** A fundamental measure is to reduce the production and consumption of single-use plastics, such as bags, bottles, and disposable utensils. This implies promoting the use of more sustainable alternatives, such as reusable bags, refillable bottles and products of biodegradable origin.

**-Improvement of waste management.** It is essential to implement efficient waste management systems that promote the collection, recycling and proper treatment of plastics. This includes public education on the importance of waste separation and promoting consumer responsibility to reduce plastic pollution.

**-Sewage treatment.** Wastewater treatment plants must improve their processes to effectively remove microplastics present in wastewater before they are released into the environment. Advanced filtration and separation technologies must be implemented to effectively capture and remove microplastics.

**- Research and monitoring.** Further research on the effects of microplastics in water and on human health is essential. This implies carrying out long-term monitoring studies to assess their presence in different bodies of water and determine the possible impacts on ecosystems and human health. Research should also focus on developing more accurate detection and analysis methods to assess quantity and composition.

**-Promotion of awareness and education.** It is essential to raise awareness about the problems related to microplastics in water, both among the general population and among decision makers. Awareness campaigns should be carried out to inform about the risks and promote behavioral changes in reducing the consumption of plastics and in adopting more sustainable practices.

**-International cooperation.** Given Since microplastic pollution is a global problem, international cooperation is required to address it effectively. Countries must collaborate on the formulation of stricter policies and regulations to reduce the production and use of plastics, as well as to improve waste management and the protection of water resources.

Therefore, integrated and coordinated actions are needed at a global level to address the impact of microplastics on water and human health. This implies the reduction of the consumption of plastics, the improvement of waste management, the adequate treatment of wastewater, continuous research, public education and international cooperation. With collective efforts and effective measures, we can work towards the protection of our aquatic ecosystems and the preservation of human health.[6,24,36,38]

**Determination of Microplastics In Waters**

The determination of microplastics in water is a field of research in constant development due to the growing concern about the environmental impact of these pollutants.

It is important to highlight that the determination of microplastics in water can be a complex process and requires specialized equipment and techniques. In addition, it is necessary to carry out an adequate preparation and treatment of the samples before applying the analytical methods to minimize possible interferences and ensure accurate results.

The determination of microplastics in water can be carried out by different analytical methods. Some of the most common methods used are[40-47]

**-Filtration.** This method involves filtering a known volume of water through membranes or fine pore filters to retain any microplastics present. The microplastics are then recovered from the filters and quantified and characterized using microscopy or spectroscopy techniques.

**-Fourier transform infrared spectroscopy (FTIR).** FTIR spectroscopy is used to identify and quantify microplastics in water samples. This technique is based on the measurement of the unique molecular vibrations of plastics, which allows their identification.

**- Fluorescence microscopy:** Microplastics can be labeled with fluorescent dyes for detection and quantification using fluorescence microscopy. This technique allows direct visualization of microplastics and is widely used for the identification and characterization of particles in water samples.

**-Electrospray ionization mass spectrometry (ESI-MS).** ESI-MS is a technique used for the identification and quantification of microplastics in water. It is based on the ionization of microplastics in solution and their subsequent analysis by mass spectrometry, which allows the determination of the chemical composition of the microplastics present.

**-Raman spectroscopy.** Raman spectroscopy is based on the interaction of light with molecules and allows the identification of microplastics based on their unique spectral characteristics. This technique is used to analyze the chemical composition of microplastics present in water samples.

**-Scanning electron microscopy (SEM).** SEM is a high-resolution technique that allows direct visualization of microplastics in water samples. In addition to providing information about the shape and size of microplastics, SEM can also be used to perform energy dispersive X-ray (EDX) analysis and determine the elemental composition of particles.

**-High resolution mass spectrometry (HRMS).** HRMS is an advanced analytical technique that allows the identification and quantification of microplastics in water with high precision. This technique is based on the measurement of the mass-charge relationship of the particles and its comparison with a reference database.

**-Atomic force microscopy (AFM) and scanning atomic force microscopy (SFAM)** techniques. These techniques allow the observation and characterization of microplastics at the nanometric scale. AFM and SFAM can be used to measure particle roughness, assess surface interactions, and determine the morphology and mechanical properties of microplastics.

**-Advanced chemical analysis techniques.** Various advanced analytical techniques are being developed and applied for the identification and quantification of microplastics, such as time-of-flight mass spectrometry (TOF-MS), high performance liquid chromatography (HPLC), and isotope ratio mass spectrometry. (IRMS).

It is important to keep in mind that each technique has its advantages and limitations, and the choice of method will depend on several factors, such as the type of sample, the concentration and size of the microplastics, the resources available, and the specific objectives of the study. In many cases, it is advisable to combine different techniques to obtain a more complete characterization of the microplastics present in water.

## CONCLUSIONS

The presence of microplastics in water is an increasingly important environmental and public health problem. These tiny plastic particles have multiple sources and follow various routes of contamination before entering bodies of water. Once there, microplastics have a significant impact on aquatic organisms, from the smallest microorganisms to fish, birds and marine mammals. In addition, there is growing concern about the possible effects on human health due to the ingestion of microplastics and the release of toxic chemicals associated with them.

To address this problem, concrete and coordinated actions are required. It is essential to reduce the use of single-use plastics and improve waste management to prevent them from reaching bodies of water. Likewise, it is necessary to implement advanced technologies in wastewater treatment plants to effectively capture and remove these microplastics. Research and ongoing monitoring are essential to better understand the impacts of microplastics and develop mitigation strategies.

Furthermore, awareness raising and education are powerful tools to promote behavior change in society. It is necessary to inform the population about the risks associated with microplastics in water and encourage more sustainable practices in the consumption and management of plastics. International cooperation also plays a crucial role, since microplastic pollution is a global problem that requires joint efforts and stricter policies at the global level.

Ultimately, addressing microplastics in water is a complex challenge, but it is essential to preserve the health of our aquatic ecosystems and protect human health. Through the implementation of appropriate actions, continuous research and collaboration between different sectors, we can work towards a cleaner and more sustainable future, where microplastics in water are reduced to minimum levels and aquatic ecosystems are preserved for future generations.

## BIBLIOGRAPHY


1. Wang, C. Zhao, J, Xing, B. Environmental source, fate, and toxicity of microplastics. J. Hazard. Mater, 2020; 407: 124357, 2021, doi: 10.1016/j.jhazmat.2020.124357.
2. Andrady, AL The plastic in microplastics: A review. Marine Pollution Bulletin, 2017; 119(1): 12-22.
3. Rochman, CM. The complex mixture, fate and toxicity of chemicals associated with plastic debris in the marine environment. In Marine Anthropogenic Litter, 2015; 117-140.
4. Hartmann, NB, Hüffer, T, Thompson, RC., Hassellöv, M. Are we speaking the same language? Recommendations for a definition and categorization framework for plastic debris. Environmental Science & Technology, 2019; 53(3): 1039-1047.
5. Eriksen, M., Lebreton, LC, Carson, HS, Thiel, M., Moore, CJ, Borerro, JC, Reisser, J. Plastic pollution in the world's oceans: more than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PloS one, 2014; 9(12): e111913.
6. Wright, SL., Kelly, FJ. Plastic and human health: A micro issue?. Environmental Science & Technology, 2017; 51(12): 6634-6647.
7. Galloway, T.S., Lewis, C.N. Marine microplastics spell big problems for future generations. Proceedings of the National Academy of Sciences, 2016; 113(9): 2331-2333.
8. Silver JC. Airborne microplastics: Consequences to human health? Environmental Pollut, 2018; 234: 115-26.
9. Cesa, FS, A. Turra, HH Checon, B. Leonardi, J. Baruque-Ramos. Laundering and textile parameters influence fibers release in household washings. Environ. Pollut., 2020; 257: 113553. doi: https://doi.org/10.1016 /j.envpol.2019.113553.
10. F. Petersen and JA Hubbart, The occurrence and transport of microplastics: The state of the science. Sci. Total Environ, 2021; 758: 143936. doi: 10.1016/j.scitotenv.2020.143936.
11. Horton, AA, A. Walton, DJ Spurgeon, E. Lahive, and C. Svendsen, "Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities," Sci. Total Environ, 2017; 586: 127–141. doi: https://doi.org/10.1016/j.scitotenv.2017.01.190.
12. Chae Y., YJ An. Current research trends on plastic pollution and ecological impacts on the soil ecosystem: A review, Environ. Pollut., 2018; 240: 387–395. doi: https://doi.org/10.1016/j.envpol.2018.05.008.
13. Dris, R., J. Gasperi, M. Saad, C. Mirande, and B. Tassin, Synthetic fibers in atmospheric fallout: A source of microplastics in the environment?. Mar. Pollut. Bull, 2016; 104(1): 290–293. doi: https://doi.org/10.1016 /j.marpolbul.2016.01.006.
14. ter Halle, A, L. Ladirat, M. Martignac, AF Mingotaud, O. Boyron, and E. Perez, To what extent are microplastics from the open ocean weathered?. Environ. Pollut, 2017; 227: 167–174. doi: 10.1016/J.ENVPOL.2017.04.051.
15. Thompson RC, Moore CJ, vom Saal FS, Swan SH. Plastics, the environment and human health: current consensus and future trends. Philos Trans R Soc B Biol Sci., 2009; 364(1526): 2153-66.
16. Kotoyori, T. Activation energy for the oxidative thermal degradation of plastics. Thermochim. Act, 1972; 5(1): 51–58. doi: https://doi.org/10.1016/0040-6031(72)80018-2 .
17. S. Wagner, T. Hüffer, P. Klöckner, M. Wehrhahn, T. Hofmann, T. Reemtsma, Tire wear particles in the aquatic environment. A review on generation, analysis, occurrence, fate and effects. Water Res., 2018; 139: 83–100. doi: https://doi.org/10.1016/j.watres.2018.03.051.
18. McKeen LW Introduction to the Physical, Mechanical, and Thermal Properties of Plastics and Elastomers. Eff. Long Term Therm. Expo. plast. Elastomers, 2014; 43–71. doi: 10.1016/B978-0-323-22108-5.00003-5.
19. Arhant, M., M. Le Gall, PY Le Gac, P. Davies. Impact of hydrolytic degradation on mechanical properties of PET - Towards an understanding of microplastics formation. Polym. Degrade Stab, 2019; 161: 175–182. doi: 10.1016/J.POLYMDEGRADSTAB.2019.01.021.
20. Sjollema SB, Redondo-Hasselerharm P, Leslie HA, Kraak MHS, Vethaak AD. Do plastic particles affect microalgal photosynthesis and growth? Aquat toxicol, 2016; 170: 259-61.
21. Waring RH, Harris RM, Mitchell SC. Plastic contamination of the food chain: A threat to human health? Maturitas, 2018; 115: 64-8.
22. Yang, H, M. Ma, JR Thompson, RJ Flower. Waste management, informal recycling, environmental pollution and public health. J Epidemiol Community Heal, 2018; 72(3): 237–243. doi: 10.1136/JECH-2016-208597.
23. Nizzetto, L., M. Futter, S. Langaas, Are Agricultural Soils Dumps for Microplastics of Urban Origin?.

Environ. Sci. Technol, 2016; 50(20): 10777–10779. doi: 10.1021/acs.est.6b04140.
24. Sadri SS, Thompson RC. On the quantity and composition of floating plastic debris entering and leaving the Tamar Estuary, Southwest England. Sea Pollut Bull, 2014; 81(1): 55-60.
25. Horton, AA, C. Svendsen, RJ Williams, DJ Spurgeon, E. Lahive. Large microplastic particles in sediments of tributaries of the River Thames, UK–Abundance, sources and methods for effective quantification. Mar. Pollut. Bull, 2017; 114(1): 218–226. doi: https://doi.org/10.1016/j.marpolbul.2016.09.004.
26. Hoellein, TJ, AJ Shogren, JL Tank, P. Risteca, JJ. Kelly. Microplastic deposition velocity in streams follows patterns for naturally occurring allochthonous particles. Sci. Rep, 2019; 9: 1. doi: 10.1038/s41598-019-40126-3.
27. Prata, JC, JP da Costa, I. Lopes, AC Duarte, and T. Rocha-Santos, Environmental exposure to microplastics: An overview on possible human health effects. Sci. Total Environ, 2020; 702: 134455. doi: https://doi.org/10.1016/j.scitotenv.2019.134455.
28. Park, TJ, S.-H. Lee, M.-S. Lee, J.-K. Lee, S.-H. Lee, and K.-D. Zoh, Occurrence of microplastics in the Han River and riverine fish in South Korea. Sci. Total Environ, 2020; 708: 134535. doi: https://doi.org/10.1016/j.scitotenv.2019.134535.
29. Murphy, F., C. Ewins, F. Carbonnier, B. Quinn, Wastewater Treatment Works (WwTW) as a Source of Microplastics in the Aquatic Environment. Environ. Sci. Technol, 2016; 50(11): 5800–5808. doi: 10.1021/acs.est.5b05416.
30. Hwang, J., D. Choi, S. Han, J. Choi, J. Hong, An assessment of the toxicity of polypropylene microplastics in human derived cells. Sci. Total Environ, 2019; 684: 657–669. doi: https://doi.org/10.1016/j.scitotenv.2019.05.071.
31. Rahman, A., A. Sarkar, OP Yadav, G. Achari, J. Slobodnik. Potential human health risks due to environmental exposure to nano- and microplastics and knowledge gaps: A scoping review. Sci. Total Environ., 2021; 757: 143872. doi: 10.1016/j.scitotenv.2020.143872.
32. Sun, J., X. Dai, Q. Wang, MCM van Loosdrecht, BJNi. Microplastics in wastewater treatment plants: Detection, occurrence and removal," Water Research, vol. 152. Elsevier Ltd., 2019; 21–37: 01. doi: 10.1016/j.watres.2018.12.050.
33. Cole, M., P. Lindeque, C. Halsband, and TS Galloway, Microplastics as contaminants in the marine environment: A review. Mar. Pollut. Bull, 2011; 62(12): 2588–2597. doi: https://doi.org/10.1016/j.marpolbul.2011.09.025.
34. Cox, KD, Covernton GA, Davies HL, Dower JF, Juanes F., Dudas SE, Human Consumption of Microplastics. Environ. Sci. Technol, June 2019; 53(12): 7068–7074. doi: 10.1021/acs.est.9b01517.
35. Muller-Karanassos, C., A. Turner, W. Arundel, T. Vance, PK Lindeque, M. Cole, Antifouling paint particles in intertidal estuarine sediments from southwest England and their ingestion by the harbor ragworm, Hediste diversicolor. Environ. Pollut, 2019; 249: 163–170. doi: https://doi.org/10.1016/j.envpol.2019.03.009.
36. Deng, Y., Y. Zhang, B. Lemos, H. Ren, Tissue accumulation of microplastics in mice and biomarker responses suggest widespread health risks of exposure. Sci. Rep., 2017; 7(1): 46687. doi: 10.1038/srep46687.
37. Revel, MA Châtel, C. Mouneyrac, Micro(nano)plastics: A threat to human health?. curr. Opinion. Environ. Sci.Heal., 2018; 1, 17–23. doi: https://doi.org/10.1016/j.coesh.2017.10.003.
38. Rist, SB Carney Almroth, NB Hartmann, TM Karlsson, A critical perspective on early communications concerning human health aspects of microplastics. Sci. Total Environ, 2018; 626: 720–726. doi: https://doi.org/10.1016/j.scitotenv.2018.01.092.
39. Ziajahromi, S, Neale PA, Rintoul L, Leusch FDL. Wastewater treatment plants as a pathway for microplastics: Development of a new approach to sample wastewater-based microplastics. Water Res., 2017; 112: 93–99. doi: https://doi.org/10.1016/j.watres.2017.01.042.
40. Prata, JC, JP da Costa, AC Duarte, T. Rocha-Santos, Methods for sampling and detection of microplastics in water and sediment: A critical 80 review. TrAC Trends Anal. Chem., 2019; 110: 150–159. doi: https://doi.org/10.1016/j.trac.2018.10.029.
41. Roland, G., JJR, LK Lavender. Production, use, and fate of all plastics ever made. Sci.Adv, 2021; 3: 7. p.e1700782, doi: 10.1126/sciadv.1700782.
42. Magnusson, K., F. Norén, Screening of microplastic particles in and downstream a wastewater treatment plant," IVL Swedish Environ. Res. Inst., vol. C55, no. C, 2014; 22.
43. Hidalgo-Ruz, VL Gutow, RC Thompson, M. Thiel, Microplastics in the marine environment: A review of the methods used for identification and quantification. Environ. Sci. Technol., 2012; 46(6): 3060–3075. doi: 10.1021/es2031505.
44. Löder, MGJ., M. Kuczera, S. Mintenig, C. Lorenz, G. Gerdts, Focal plane array detector-based micro-Fourier-transform infrared imaging for the analysis of microplastics in environmental samples. Environ. Chem., 2015; 12(5): 563–581. Available: https://doi.org/10.1071/EN14205.
45. Rocha-Santos, T., AC Duarte, A critical overview of the analytical approaches to the occurrence, the fate and the behavior of microplastics in the environment TrAC Trends Anal. Chem., 2015; 65: 47–53. doi: https://doi.org/10.1016/j.trac.2014.10.011.
46. Uheida, A., HG Mejía, M. Abdel-Rehim, W. Hamd, J. Dutta, Visible light photocatalytic degradation of polypropylene microplastics in a continuous water

flow system. J. Hazard. Mater., 2020; 406: 124299, 2021. doi: 10.1016/j.jhazmat.2020.124299.

47. Talvitie, J., A. Mikola, A. Koistinen, and O. Setälä, Solutions to microplastic pollution Removal of microplastics from wastewater effluent with advanced wastewater treatment technologies. Water Res., 2017; 123: 401–407. doi: https://doi.org/10.1016/j.watres.2017.07.005.