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[Volume 181](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/journal/water-research/vol/181/suppl/C), 15 August 2020, 115931

**Review**

**Making waves: Water-soluble polymers in the aquatic environment: An overlooked class of synthetic polymers?**

Author links open overlay panel[SvenHuppertsberg](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[a1](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[DanielZahn](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[a1](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[FrancesPauelsen](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[a](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[ThorstenReemtsma](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[bc](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[Thomas P.Knepper](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)[a](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0043135420304681?via%3Dihub" \l "!)

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**Highlights**

•

WSP are high volume chemicals.

•

Applications of WSP facilitate discharge in the environment.

•

Environmental data for WSP still scarce.

•

There are no established trace analytical methods for WSP in the environment.

•

Development of a new approach for the detection of WSP as sum parameter is required.

**Abstract**

Synthetic polymers have been one of the defining environmental topics of the last decade. Synthetic polymers in the environment are usually classified by their size. They encompass the widely discussed size fractions of macroplastic, microplastic, and nanoplastic. Water-soluble polymers (WSPs), however, are mostly absent in this discussion. In this paper, we argue that WSPs are produced in large quantities and have many applications that facilitate a discharge into the environment, where their fate and impact remain mostly unclear. We argue that there are yet no suitable analytical methods for the quantification of WSPs in environmental matrices and propose an analytical method that utilizes size exclusion chromatography - mass spectrometry to detect and potentially also quantify WSPs through specific fragments generated by in-source fragmentation. With the detection of polyethylene glycol in a wastewater treatment plant effluent and a surface water sample we provide a first prove of principle for the applicability of this novel analytical approach to WSPs. Ultimately, we conclude that WSPs are currently in a similar position as MP were in the advent of their investigation: We know of an environmental contamination but are uncertain of its extent and impact and still lack the tools to investigate them thoroughly.

**Graphical abstract**

## Mechanical degradation of water-soluble acrylamide copolymer under a turbulent flow: Effect of molecular weight and temperature

### By:

[Zhang, Ke](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AU%22,%22rowText%22:%22Zhang,%20Ke%22%7D%5D&eventMode=oneClickSearch); [Choi, Hyoung Jin](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AU%22,%22rowText%22:%22Choi,%20Hyoung%20Jin%22%7D%5D&eventMode=oneClickSearch)

### By:

[임가현](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/KJD/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AU%22,%22rowText%22:%22%EC%9E%84%EA%B0%80%ED%98%84%22%7D%5D&eventMode=oneClickSearch)

Journal of Industrial and Engineering Chemistry

### Volume

33

### Page

156-161

### DOI

10.1016/j.jiec.2015.09.031

### Published

JAN 23 2016

### Indexed

2016-01-23

### Document Type

Article

## Abstract

An experimental study of the turbulent drag reduction (DR) performance of water-solublepoly(acrylamide-co-acrylic acid) copolymers with two different molecular weights in a rotating diskapparatus is reported. The DR efficiency of very dilute polymer solutions was measured to relate their DRactivity to molecular parameters, such as molecular weight, concentration, temperature, and rotationalspeed of the disk. Experimental results show that polymers with high molecular weights and highconcentrations exhibit a persistent DR activity to mechanical degradation under a turbulent flow.

## Keywords

### Author Keywords

[Polymer degradation](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AK%22,%22rowText%22:%22%5C%22Polymer%20degradation%5C%22%22%7D%5D&eventMode=oneClickSearch)[Drag reduction](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AK%22,%22rowText%22:%22%5C%22Drag%20reduction%5C%22%22%7D%5D&eventMode=oneClickSearch)[Turbulent flow](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AK%22,%22rowText%22:%22%5C%22Turbulent%20flow%5C%22%22%7D%5D&eventMode=oneClickSearch)[Copolymer](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22AK%22,%22rowText%22:%22%5C%22Copolymer%5C%22%22%7D%5D&eventMode=oneClickSearch)

### Keywords Plus

[DRAG REDUCTION](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22KP%22,%22rowText%22:%22%5C%22DRAG%20REDUCTION%5C%22%22%7D%5D&eventMode=oneClickSearch)[POLY(ETHYLENE OXIDE)](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22KP%22,%22rowText%22:%22%5C%22POLY(ETHYLENE%20OXIDE)%5C%22%22%7D%5D&eventMode=oneClickSearch)[DILUTE-SOLUTIONS](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22KP%22,%22rowText%22:%22%5C%22DILUTE-SOLUTIONS%5C%22%22%7D%5D&eventMode=oneClickSearch)[POLYACRYLAMIDE](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22KP%22,%22rowText%22:%22%5C%22POLYACRYLAMIDE%5C%22%22%7D%5D&eventMode=oneClickSearch)[POLYMERS](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22KP%22,%22rowText%22:%22%5C%22POLYMERS%5C%22%22%7D%5D&eventMode=oneClickSearch)[BEHAVIOR](https://www-webofscience-com.proxy.ub.uni-frankfurt.de/wos/woscc/general-summary?queryJson=%5B%7B%22rowBoolean%22:null,%22rowField%22:%22KP%22,%22rowText%22:%22%5C%22BEHAVIOR%5C%22%22%7D%5D&eventMode=oneClickSearch)

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## Categories/Classification

### Research Areas

ChemistryEngineering

## [Science of The Total Environment](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/journal/science-of-the-total-environment)

[Volume 806, Part 2](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/journal/science-of-the-total-environment/vol/806/part/P2), 1 February 2022, 150603

# Photocatalytic and biological technologies for elimination of microplastics in water: Current status

Author links open overlay panel[ParisaEbrahimbabaie](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0048969721056813?via%3Dihub" \l "!)[a](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0048969721056813?via%3Dihub" \l "!)[KimiyaYousefi](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0048969721056813?via%3Dihub" \l "!)[b](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0048969721056813?via%3Dihub" \l "!)[JohnPichtel](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0048969721056813?via%3Dihub" \l "!)[a](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/science/article/abs/pii/S0048969721056813?via%3Dihub" \l "!)

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## Highlights

•

Tens of millions of tons of microplastics occur in freshwater and oceans.

•

Microplastics can be captured, but few technologies are available for destruction.

•

Photocatalytic and microbial technologies show promise for microplastics elimination.

•

The use of combined technologies for MP elimination should be considered.

## Abstract

Water pollution by microplastics (MPs) has emerged as a significant environmental and public health concern. Several conventional technologies in drinking water and [wastewater treatment](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/topics/earth-and-planetary-sciences/wastewater-treatment) facilities are capable of capturing a substantial portion of microplastics from surface water; however, only limited methods are available for actual destruction of microplastics. Rate of success is highly variable, and actual mechanisms which result in MP destruction are only partly known. [Photocatalysis](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/topics/earth-and-planetary-sciences/photocatalysis" \o "Learn more about Photocatalysis from ScienceDirect's AI-generated Topic Pages) and microbial degradation technologies show promise at laboratory scale for the transformation of microplastics to water-soluble hydrocarbons, carbon dioxide and, in limited cases, useful fuels. Both photocatalytic and microbial technologies offer the potential for long-term water security and ecological stability and deserve further attention by scientists. Additional research is necessary, however, in identifying more effective semiconductors for photocatalysis, and optimal effective microbial consortia and environmental conditions to optimize microplastic biodegradation. Many more polymer types beyond [polyethylene](https://www-sciencedirect-com.proxy.ub.uni-frankfurt.de/topics/earth-and-planetary-sciences/polyethylene) must be studied for degradation, and laboratory-scale research must be expanded to field-scale. This paper provides a comprehensive overview of processes and mechanisms for removing MPs by photocatalysis and microbial technologies. It provides useful data for research dedicated to improved removal of MPs from surface waters.

## Graphical abstract

Photocatalytic and biological technologies for degradation of microplastics in water.

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# Advances in Ultra-Trace Analytical Capability for Micro/Nanoplastics and Water-Soluble Polymers in the Environment: Fresh Falling Urban Snow[☆](https://www.sciencedirect.com/science/article/abs/pii/S0269749121002773?via%3Dihub" \l "aep-article-footnote-id6)

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## Highlights

•

There are soluble micro/nanoplastic particles in fresh falling snow in an urban setting.

•

In-laboratory built NALDI-MS lead to ultra-trace quantification detection.

•

Picogram quantification has been achieved for both soluble and insoluble plastics.

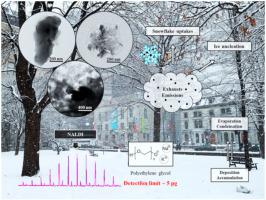
•

In-laboratory built nanostructures can be recyclable and sustainable.

## Abstract

Discarded micro/nano-plastic inputs into the environment are emerging global concerns. Yet the quantification of micro/nanoplastics in complex environmental matrices is still a major challenge, notably for soluble ones. We herein develop in-laboratory built nanostructures (zinc oxide, titanium oxide and cobalt) coupled to mass spectrometry techniques, for picogram quantification of micro/nanoplastics in water and snow matrices, without sample pre-treatment. In parallel, an ultra-trace quantification method for micro/nanoplastics based on nanostructured laser desorption/ionization time-of-flight mass spectrometry (NALDI-TOF-MS) is developed. The detection limit is ∼5 pg for ambient snow. Soluble [polyethylene](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/polyethylene) glycol and insoluble polyethylene fragments were observed and quantified in fresh falling snow in Montreal, Canada. Complementary physicochemical studies of the snow matrices and reference plastics using laser-based particle sizers, inductively coupled plasma tandem mass spectrometry, and high-resolution scanning/transmission electron microscopy, produced consistent results with NALDI, and further provided information on morphology and composition of the micro/nano-plastic particles. This work is promising as it demonstrates that a wide range of recyclable nanostructures, in-laboratory built or commercial, can provide ultra-trace capability for quantification for both soluble polymers and insoluble plastics in air, water and soil. It may thereby produce key missing information to determine the fate of micro/nanoplastics in the environment, and their impacts on human health.

## Graphical abstract



# Micro (nano) plastics in wastewater: A critical review on toxicity risk assessment, behaviour, environmental impact and challenges

Author links open overlay panel[SimranjeetSingha1T. S. SunilKumar Naikb1Amith G.Anilb1JaskaranDhimanc1VijayKumard](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub#!)[Daljeet SinghDhanjal](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[e](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[LilianaAguilar-Marcelino](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[f](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[JoginderSingh](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[e](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[Praveen C.Ramamurthy](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)[a](https://www.sciencedirect.com/science/article/abs/pii/S0045653521036419?via%3Dihub" \l "!)

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## Highlights

•

Degradation of micro (nano) plastics and its toxicity in the environment are discussed.

•

Micro (nano) sources, detection, risk, fate, and future challenges are presented.

•

Opinion on micro (nano) removal techniques, recovery and reuse are provided.

•

Development of sensors to assess micro (nano) plastics are suggested in future work.

## Abstract

With millions of tonnes of plastic pollution generated every year, small-sized plastic particles, including micro- and nanoplastics, end up in freshwater systems. Due to the very small size and very large specific surface area of nanoplastics, they are known to be persistent and toxic in our environment. These particles are also known to react with other water-borne contaminants and cause acute toxicity in organisms. Nanoplastics are prone to [biomagnification](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/biomagnification" \o "Learn more about biomagnification from ScienceDirect's AI-generated Topic Pages) and can be transported to humans through various pathways. This study aims to contribute towards understanding the behaviour of nanoplastics in our environment, specifically through identification of various sources, detection techniques, toxicity estimation, health risk in humans, [environmental fate](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/environmental-fate), recovery and reuse, and future challenges and limitations. Detailed review on the toxic effects of nanoplastics on various organisms and their degradation rates in soil and water matrices are provided. The suitability of small- and large-scale separation techniques for the removal of nanoplastics in [wastewater treatment plants](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/waste-water-treatment-plant) is also discussed. Current challenges and future perspectives in understanding the fate and transport of nanoplastics in the environment are also discussed. Research gaps, including the development of quantification techniques, estimation of degradation mechanisms, transport in marine ecosystems, and development of sensors to examine nanoplastics in the environment, are explored. Finally, we can limit the release of nanoplastics to the environment through reduction, reuse and recycling (3 Rs) of bulk plastic products.

## Graphical abstract

# Water-soluble polymeric xenobiotics - Polyvinyl alcohol and polyvinylpyrrolidon - And potential solutions to environmental issues: A brief review

[Markéta Julinová](https://pubmed.ncbi.nlm.nih.gov/?term=Julinov%C3%A1+M&cauthor_id=30223180)[1](https://pubmed.ncbi.nlm.nih.gov/30223180/#affiliation-1), [Ludmila Vaňharová](https://pubmed.ncbi.nlm.nih.gov/?term=Va%C5%88harov%C3%A1+L&cauthor_id=30223180)[2](https://pubmed.ncbi.nlm.nih.gov/30223180/#affiliation-2), [Martin Jurča](https://pubmed.ncbi.nlm.nih.gov/?term=Jur%C4%8Da+M&cauthor_id=30223180)[2](https://pubmed.ncbi.nlm.nih.gov/30223180/#affiliation-2)

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* PMID: 30223180

* DOI: [10.1016/j.jenvman.2018.09.010](https://doi.org/10.1016/j.jenvman.2018.09.010)

**Abstract**

This paper describes a potential environmental problem closely linked with the global production of water-soluble polymers such as polyvinyl alcohol (PVA) and polyvinylpyrrolidone (PVP). Both polymers make up the components of a multitude of products commonly utilized by industries and households. Hence, such a widespread use of PVA and PVP in the industrial sector and among consumers (the concentration of PVP in urban wastewater is approximately 7 mg/L) could pose a considerable problem, particularly to the environment. To this end, many publications have recently highlighted the poor biodegradability of PVA, in principle influenced by numerous biotic and abiotic factors. Facts published on the environmental fate of PVP have been scant, basically reporting that it is a biologically resistant polymer. As a result, the commercially produced water-soluble polymers of PVA and PVP are essentially non-biodegradable and possess the capacity to accumulate in virtually all environmental media. Consequently, there is a chance of heightened risk to the very environmental constituents in which PVA and PVP accumulate, depending on the routes of entry and transformation processes underway in such constituents of the ecosystem. This assumption is confirmed by the findings of initial research, which is worrying. Herein, PVA was detected in a soil environment, while a relatively high concentration of PVP was found in river water. A review of the literature was conducted to summarize the current state of knowledge concerning the fate of PVA and PVP in various environments, thereby also discerning potential solutions to tackle such dangers. This paper proposes methods to enhance the biodegradability of materials containing such materials; for PVA this means utilizing a suitable polysaccharide, whereas for PVP this pertains to actuating applications that induce substances to degrade. Accordingly, while it is understandable that this work cannot fully address all the issues associated with polymeric xenobiotics, it can still serve as a guide to discerning an economically viable solution, and provide a foundation for further research.

**Keywords:**Biodegradation; Blends; Environmental fate; Polymeric xenobiotics; Polyvinyl alcohol; Polyvinylpyrrolidone.

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A **xenobiotic** is a chemical substance found within an [organism](https://en.wikipedia.org/wiki/Organism) that is not naturally produced or expected to be present within the organism. It can also cover substances that are present in much higher [concentrations](https://en.wikipedia.org/wiki/Concentration) than are usual. Natural compounds can also become xenobiotics if they are taken up by another organism, such as the uptake of natural human hormones by fish found downstream of sewage treatment plant outfalls, or the chemical defenses produced by some organisms as protection against predators.[[1]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-Mansuy-1)

The term **xenobiotics**, however, is very often used in the context of pollutants such as [dioxins](https://en.wikipedia.org/wiki/Polychlorinated_dibenzodioxins) and [polychlorinated biphenyls](https://en.wikipedia.org/wiki/Polychlorinated_biphenyl) and their effect on the [biota](https://en.wikipedia.org/wiki/Biota_(ecology)), because xenobiotics are understood as substances foreign to an entire biological system, i.e. artificial substances, which did not exist in nature before their synthesis by humans. The term xenobiotic [is derived from the Greek words ξένος (xenos) = foreigner, stranger](https://en.wiktionary.org/wiki/xeno-) and βίος (bios) = life, plus the Greek suffix for adjectives -τικός, -ή, -όν (-tikos, -ē, -on).

Xenobiotics may be grouped as [carcinogens](https://en.wikipedia.org/wiki/Carcinogen), drugs, environmental pollutants, [food additives](https://en.wikipedia.org/wiki/Food_additive), [hydrocarbons](https://en.wikipedia.org/wiki/Hydrocarbons), and pesticides.



**Contents**

* [1Xenobiotic metabolism](https://en.wikipedia.org/wiki/Xenobiotic#Xenobiotic_metabolism)
* [2Xenobiotics in the environment](https://en.wikipedia.org/wiki/Xenobiotic#Xenobiotics_in_the_environment)
* [3Inter-species organ transplantation](https://en.wikipedia.org/wiki/Xenobiotic#Inter-species_organ_transplantation)
* [4See also](https://en.wikipedia.org/wiki/Xenobiotic#See_also)
* [5References](https://en.wikipedia.org/wiki/Xenobiotic#References)

Xenobiotic metabolism[[edit](https://en.wikipedia.org/w/index.php?title=Xenobiotic&action=edit&section=1" \o "Edit section: Xenobiotic metabolism)]

The body removes xenobiotics by [xenobiotic metabolism](https://en.wikipedia.org/wiki/Xenobiotic_metabolism). This consists of the deactivation and the excretion of xenobiotics and happens mostly in the liver. Excretion routes are urine, feces, breath, and sweat. Hepatic enzymes are responsible for the metabolism of xenobiotics by first activating them (oxidation, reduction, hydrolysis, and/or hydration of the xenobiotic), and then conjugating the active secondary metabolite with [glucuronic acid](https://en.wikipedia.org/wiki/Glucuronic_acid), [sulfuric acid](https://en.wikipedia.org/wiki/Sulfuric_acid), or [glutathione](https://en.wikipedia.org/wiki/Glutathione), followed by excretion in bile or urine. An example of a group of enzymes involved in xenobiotic metabolism is hepatic microsomal [cytochrome P450](https://en.wikipedia.org/wiki/Cytochrome_P450). These enzymes that metabolize xenobiotics are very important for the pharmaceutical industry because they are responsible for the breakdown of medications. A species with this unique cytochrome P450 system is [Drosophila mettleri](https://en.wikipedia.org/wiki/Drosophila_mettleri), which uses xenobiotic resistance to exploit a wider nesting range including both soil moistened with necrotic exudates and necrotic plots themselves.

Although the body is able to remove xenobiotics by reducing it to a less toxic form through xenobiotic metabolism then excreting it, it is also possible for it to be converted into a more toxic form in some cases. This process is referred to as [bioactivation](https://en.wikipedia.org/wiki/Bioactivation" \o "Bioactivation) and can result in structural and functional changes to the microbiota.[[2]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:02-2) Exposure to xenobiotics can disrupt the microbiome community structure, either by increasing or decreasing the size of certain bacterial populations depending on the substance. Functional changes that result vary depending on the substance and can include increased expression in genes involved in stress response and [antibiotic resistance](https://en.wikipedia.org/wiki/Antimicrobial_resistance), changes in the levels of metabolites produced, etc.[[3]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:12-3)

Organisms can also [evolve](https://en.wikipedia.org/wiki/Evolution) to tolerate xenobiotics. An example is the [co-evolution](https://en.wikipedia.org/wiki/Co-evolution) of the production of [tetrodotoxin](https://en.wikipedia.org/wiki/Tetrodotoxin" \o "Tetrodotoxin) in the [rough-skinned newt](https://en.wikipedia.org/wiki/Rough-skinned_newt) and the evolution of tetrodotoxin resistance in its predator, the [Common Garter Snake](https://en.wikipedia.org/wiki/Common_Garter_Snake). In this predator–prey pair, an [evolutionary arms race](https://en.wikipedia.org/wiki/Evolutionary_arms_race) has produced high levels of toxin in the newt and correspondingly high levels of resistance in the snake.[[4]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:22-4) This evolutionary response is based on the snake evolving modified forms of the [ion channels](https://en.wikipedia.org/wiki/Ion_channel) that the toxin acts upon, so becoming resistant to its effects.[[5]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:32-5) Another example of a xenobiotic tolerance mechanism is the use of [ATP-binding cassette (ABC) transporters](https://en.wikipedia.org/wiki/ATP-binding_cassette_transporter), which is largely exhibited in insects.[[6]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:4-6) Such transporters contribute to resistance by enabling the transport of toxins across the cell membrane, thus preventing accumulation of these substances within cells.

Xenobiotics in the environment[[edit](https://en.wikipedia.org/w/index.php?title=Xenobiotic&action=edit&section=2" \o "Edit section: Xenobiotics in the environment)]

*Main article:*[*Environmental xenobiotic*](https://en.wikipedia.org/wiki/Environmental_xenobiotic)

Xenobiotic substances are an issue for sewage treatment systems, since they are many in number, and each will present its own problems as to how to remove them (and whether it is worth trying to)

Some xenobiotics substances are resistant to degradation. Xenobiotics such as [polychlorinated biphenyls](https://en.wikipedia.org/wiki/Polychlorinated_biphenyls) (PCBs), [polycyclic aromatic hydrocarbons](https://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbons) (PAHs), and [trichloroethylene](https://en.wikipedia.org/wiki/Trichloroethylene) (TCE) accumulate in the environment due to their recalcitrant properties and have become an environmental concern due to their toxicity and accumulation. This occurs particularly in the subsurface environment and water sources, as well as in biological systems, having the potential to impact human health.[[7]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:0-7) Some of the main sources of pollution and the introduction of xenobiotics into the environment come from large industries such as pharmaceuticals, fossil fuels, pulp and paper bleaching and agriculture.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8) For example, they may be synthetic [organochlorides](https://en.wikipedia.org/wiki/Organochloride) such as plastics and pesticides, or naturally occurring organic chemicals such as [polyaromatic hydrocarbons](https://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon" \o "Polycyclic aromatic hydrocarbon) (PAHs) and some fractions of crude oil and coal.

Microorganisms may be a viable solution to this issue of environmental pollution by the degradation of the xenobiotics; a process known as [bioremediation](https://en.wikipedia.org/wiki/Bioremediation).[[9]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:2-9) Microorganisms are able to adapt to xenobiotics introduced into the environment through [horizontal gene transfer](https://en.wikipedia.org/wiki/Horizontal_gene_transfer), in order to make use of such compounds as energy sources.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8) This process can be further altered to manipulate the metabolic pathways of microorganisms in order to degrade harmful xenobiotics under specific environmental conditions at a more desirable rate.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8) Mechanisms of bioremediation include both genetically engineering microorganisms and isolating the naturally occurring xenobiotic degrading microbes.[[9]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:2-9) Research has been conducted to identify the genes responsible for the ability of microorganisms to metabolize certain xenobiotics and it has been suggested that this research can be used in order to engineer microorganisms specifically for this purpose.[[9]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:2-9) Not only can current pathways be engineered to be expressed in other organisms, but the creation of novel pathways is a possible approach.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8)

Xenobiotics may be limited in the environment and difficult to access in areas such as the subsurface environment.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8) Degradative organisms can be engineered to increase mobility in order to access these compounds, including enhanced [chemotaxis](https://en.wikipedia.org/wiki/Chemotaxis).[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8) One limitation of the bioremediation process is that optimal conditions are required for proper metabolic functioning of certain microorganisms, which may be difficult to meet in an environmental setting.[[7]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:0-7) In some cases a single microorganism may not be capable of performing all metabolic processes required for degradation of a xenobiotic compound and so “syntrophic bacterial consortia” may be employed.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8) In this case, a group of bacteria work in conjunction, resulting in dead end products from one organism being further degraded by another organism.[[7]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:0-7) In other cases, the products of one microorganisms may inhibit the activity another, and thus a balance must be maintained.[[8]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:1-8)

Many xenobiotics produce a variety of biological effects, which is used when they are characterized using [bioassay](https://en.wikipedia.org/wiki/Bioassay). Before they can be registered for sale in most countries, xenobiotic pesticides must undergo extensive evaluation for risk factors, such as toxicity to humans, [ecotoxicity](https://en.wikipedia.org/wiki/Ecotoxicity" \o "Ecotoxicity), or persistence in the environment. For example, during the registration process, the herbicide, cloransulam-methyl was found to degrade relatively quickly in soil.[[10]](https://en.wikipedia.org/wiki/Xenobiotic#cite_note-:3-10)

Inter-species organ transplantation[[edit](https://en.wikipedia.org/w/index.php?title=Xenobiotic&action=edit&section=3)]

*Main article:*[*Xenotransplantation*](https://en.wikipedia.org/wiki/Xenotransplantation)

The term **xenobiotic** is also used to refer to [organs](https://en.wikipedia.org/wiki/Organ_(anatomy)) [transplanted](https://en.wikipedia.org/wiki/Organ_transplant) from one [species](https://en.wikipedia.org/wiki/Species) to another. For example, some researchers hope that [hearts](https://en.wikipedia.org/wiki/Heart) and other organs could be transplanted from pigs to humans. Many people die every year whose lives could have been saved if a critical organ had been available for transplant. [Kidneys](https://en.wikipedia.org/wiki/Kidney) are currently the most commonly transplanted organ. Xenobiotic organs would need to be developed in such a way that they would not be rejected by the [immune](https://en.wikipedia.org/wiki/Immune) system.

**Acrylamide and polyacrylamide: a review of production, use, environmental fate and neurotoxicity**

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* PMID: 1668792

* DOI: [10.1515/reveh.1991.9.4.215](https://doi.org/10.1515/reveh.1991.9.4.215)

**Abstract**

Acrylamide is a highly water soluble vinyl monomer formed from the hydration of acrylonitrile. The major commercial use of acrylamide is the formation of polymers. In the environment acrylamide has a high mobility in soil, may travel great distances in ground-water, is biodegradable, and is not absorbed by sediments or affected by water treatment. It is absorbed by all routes of animal exposure. The main metabolite is N-acetyl-S-(3-amino-3-oxypropyl)-cysteine and is excreted predominantly in the urine. Acrylamide produces an ascending central/peripheral axonopathy in man and animals. The major histological findings are swelling of axons and/or decrease in number of large diameter axons. Acrylamide axonopathy is reversible with time, but full recovery depends upon the severity of the intoxication. All reported cases of acrylamide toxicity have been attributed to handling the monomer. Polyacrylamide is non-toxic. Specific clinical features of acrylamide intoxication are more conclusive than electrophysiological, histological or biochemical laboratory tests for diagnosis. Acrylamide can be detected by titration, colorimetry, high performance chromatography, gas chromatography and polarography in air, water, biological fluids, tissues and polyacrylamides. Present research on the effects of acrylamide focuses on developmental and reproductive effects, genotoxicity and carcinogenicity.