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Investigating the Occurrence, Environmental Risks and Management of Emerging Contaminants in 2026

Rutuja Ankush Waghule
Department of Microbiology, Dr. D. Y. Patil, Arts, Commerce and Science Women's College Pimpri, Pune, Maharashtra, India
*Correspondence for materials should be addressed to RAW (email: rutujawaghule62@gmail.com)

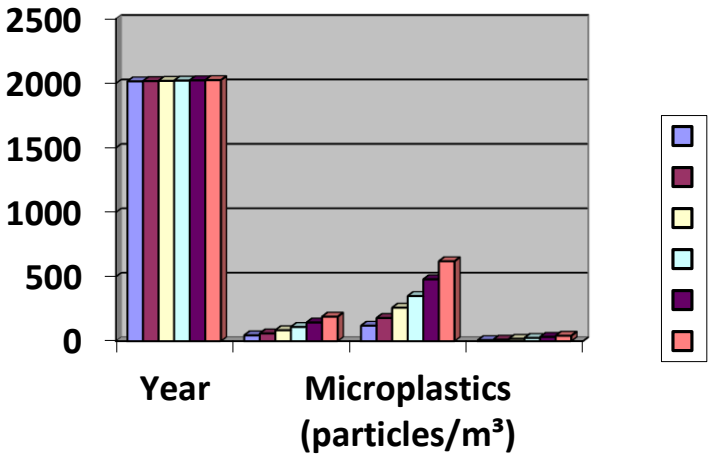
Abstract
Emerging contaminants is a group of harmful chemical substances it includes pharmaceuticals, microplastics and endocrine disrupts. They are increasingly detected in the environment due to advanced chemistry. These compounds enter aquatic and terrestrial ecosystems primarily through wastewater, agricultural runoff, and industrial discharge, improper disposal of medical trash. A significant challenge in environment water treatment systems are not currently designed to remove these substances effectively. This paper provides a comprehensives overview of the sources, environmental, and ecological risks associated with emerging contaminants (ECs).Even at low concentrations,these contaminants can cause hormonal imbalances and reproductive issues in aquatic life while contributing to global threat of antimicrobial resistance. Long-term exposure to emerging contaminants in adverse health effects , including endocrine disruption, immune system and neurological issues. This study provides an overview of the sources, occurrence, and environment fate of emerging contaminants, with a focus on their ecological and health Impacts. It also Briefly discuss current detection methods and limitations of existing treatment technologies. The paper highlights the need for improved monitoring programs, advanced treatment methods, and stronger regulatory polices to reduce the release and impact of emerging contaminants. Addressing these challenges is essential to protect environmental quality and ensure public healthy safety. Government are increasingly moving toward "source control" trying to ban certain chemicals before they ever reach the water supply.

Keywords: Environment; Ecology; Hotspots; Microorganisms; Pollutants

Introduction

Human activities such as industrial development, urban growth, agriculture, and the increased use of chemical products have led to the release of many pollutants into the environment. In recent years, scientists have become concerned about a group of pollutants known as emerging contaminants. These are substances that are not commonly monitored or fully regulated but are increasingly being found in the environment and may cause harm to living organisms and ecosystems. Emerging contaminants include pharmaceuticals, antibiotics, hormones, personal care products, pesticides, industrial chemicals, microplastics, and per- and polyfluoroalkyl substances (PFAS). These substances enter the environment through different pathways such as wastewater discharge, agricultural runoff, industrial waste, and improper disposal of household products. Many wastewater treatment plants are not designed to completely remove these contaminants, allowing them to pass into rivers, lakes, soil, and groundwater.

By 2026, improvements in scientific monitoring and detection methods will have made it easier to identify emerging contaminants at very low concentrations. Research studies show that these contaminants are now widely present in water bodies, soil, sediments, and even drinking water. Although they are often found in small amounts, their continuous release into the environment can lead to long-term exposure. Some emerging contaminants are persistent and do not break down easily, while others can accumulate in plants and animals, causing negative effects on ecosystems and human health.



The environmental risks of emerging contaminants are still not fully understood. Many of these substances are relatively new, and there is limited information about their long-term toxicity. Some emerging contaminants can interfere with the hormonal systems of organisms, reduce reproductive ability, or contribute to the development of antibiotic-resistant bacteria. In addition, these contaminants often occur as mixtures, which can increase their harmful effects compared to individual chemicals. Managing emerging contaminants is a growing challenge. Existing environmental regulations mainly focus on traditional pollutants and do not always address emerging contaminants effectively. As a result, new management strategies are needed. These include improved wastewater treatment technologies, better waste disposal practices, pollution prevention at the source, and the development of updated environmental policies. Monitoring programs and risk assessment methods also need to be improved to identify and control the most harmful contaminants.

Every year, new chemicals are created and used in industries, medicine, agriculture, and everyday products. Many of these chemicals end up in the environment—such as in water, soil, and air—even though they were not designed to be released there. These substances are called emerging contaminants. They include things like medicines, personal care products, plastics, industrial chemicals, and pesticides that are not yet fully controlled by environmental laws. By 2026, better scientific tools have shown that these contaminants are found almost everywhere in the environment, even in very small amounts. Although the amounts are low, some of these chemicals can stay in nature for a long time, build up in living organisms, and cause harm to plants, animals, and humans. Changes in climate, growing cities, and the reuse of wastewater can make these problems worse by helping contaminants spread more easily. One of the biggest challenges with emerging contaminants is that scientists still do not fully understand their long-term effects. Many of them are new, and some can change into other harmful substances once they enter the environment. Current pollution control and risk assessment methods are often not enough to deal with these chemicals.

The main objective of this study is to investigate the occurrence, environmental risks, and management of emerging contaminants in the environment in 2026. The specific objectives of the study are:

1. To identify the major types of emerging contaminants commonly found in the environment.
2. To examine the sources and pathways through which emerging contaminants enter water, soil, and other environmental compartments.
3. To assess the potential environmental and health risks associated with emerging contaminants.
4. To review current methods used for monitoring and detecting emerging contaminants.
5. To evaluate existing management and treatment strategies used to control emerging contaminants.
6. To highlight challenges and possible improvements in the management of emerging contaminants.

This study focuses on emerging contaminants present in environmental media such as surface water, groundwater, wastewater, and soil. The research mainly considers commonly reported emerging contaminants, including pharmaceuticals, personal care products, pesticides, microplastics, and industrial chemicals. The study is based on a review of recent scientific literature, reports, and case studies relevant to the year 2026.

The scope of the study is limited to understanding the general occurrence, risks, and management approaches of emerging contaminants rather than conducting laboratory experiments or field sampling. Human health impacts are discussed in relation to environmental exposure, but detailed medical or clinical effects are beyond the scope of this research. The study aims to provide a broad overview suitable for undergraduate-level understanding and to support future research and policy development.

Category	Description	Examples
Sources	Activities releasing contaminants	Industry, hospitals, agriculture
Types of ECs	New or unregulated pollutants	Drugs, PFAS, microplastics
Environmental Media	Where ECs are found	Rivers, groundwater, soil
Risks	Negative effects	Toxicity, bioaccumulation
Management	Control methods	Wastewater treatment, regulations

Literature Review

Definitions and Classification of Emerging Contaminants

Emerging contaminants (ECs) are a diverse group of pollutants that are increasingly detected in the environment but are not yet widely regulated or fully understood in terms of environmental or health effects. They include pharmaceuticals and personal care products (PPCPs), per- and polyfluoroalkyl substances (PFAS), endocrine-disrupting chemicals (EDCs), and microplastics among others. These contaminants enter ecosystems mainly through human activities such as wastewater discharge, industrial effluents, agricultural runoff, and improper disposal of waste products. Detection of ECs has grown significantly.

Occurrence and Environmental Distribution

Several reviews have shown that emerging contaminants are now widely distributed across major environmental compartments globally:

- ECs have been extensively found in water bodies and wastewater, where even low concentrations (ng/L–µg/L) can persist and accumulate due to ineffective removal by conventional treatment systems.
- Research also reports the presence of pharmaceuticals, pesticides, and other chemicals in river systems and agricultural soils, often associated with livestock farming and irrigation using treated wastewater.
- Microplastics, a key class of ECs, have been detected in freshwater ecosystems and pose a threat to aquatic life and food webs due to their pervasive distribution, multiple sources, and longevity.

A recent soil monitoring campaign found more than 520 different chemical residues, including long-banned pharmaceuticals, in English soils – indicating the persistence and widespread occurrence of ECs in terrestrial environments.

Environmental and Health Risks

Emerging contaminants pose various ecological and human health risks, often because they are persistent and biologically active even at low concentrations:

- Endocrine disruption, reproductive effects, and antibiotic resistance are major concerns linked to certain PPCPs and EDCs.
- Microplastics have been associated with toxic effects including hormone disruption and potential ingestion by humans and wildlife, raising concerns about long-term exposure risks.
- PFAS compounds are known as *"forever chemicals"* due to their high environmental persistence and potential for chronic health effects such as developmental and immune system impacts.
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Ecotoxicological studies suggest that ECs can bioaccumulate in organisms and interfere with normal biological processes, posing risks to both aquatic and terrestrial ecosystems.

Monitoring and Detection Technologies

Advances in detection and analytical methods have played a crucial role in identifying ECs at very low concentrations:

- New sensors and analytical platforms, such as ultrasensitive electrochemical sensors for PFAS, improve detection limits and allow more accurate quantification of trace contaminants in environmental samples.
- Techniques like solid phase extraction are commonly used for isolating contaminants from environmental water for further analysis.
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Despite better detection tools, systematic monitoring remains limited in many regions, especially in developing countries, making it difficult to assess the full scope of contamination and potential risks.

Management and Remediation Strategies

Addressing emerging contaminants requires a combination of technological, regulatory, and management approaches:

- **Advanced treatment technologies** such as chemical oxidation, adsorption, membrane filtration, and bioremediation are being explored to remove PFAS and other persistent ECs from water.

- Research shows that hybrid systems and novel approaches like plasma-assisted oxidation can achieve high removal efficiencies for recalcitrant contaminants in wastewater.
- However, many conventional wastewater treatment plants are still unable to fully remove ECs, underscoring the need for infrastructure upgrades and innovative technologies.

Policy and regulation also play a key role in management. Reviews indicate that current global frameworks are insufficient and highlight the need for clearer regulatory standards and monitoring programs to control EC release and protect public health.

Research Trends and Gaps

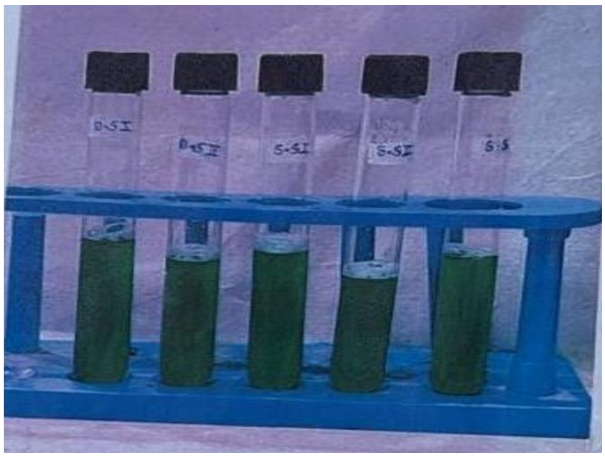
Bibliometric studies demonstrate growing scientific interest in ECs, with a significant increase in publications over the past decade. Research hotspots include degradation methods, ecological impacts, and risk assessment. However, gaps remain in understanding the long-term effects of low-level exposure, cross-media movement of contaminants, and integrated management strategies. Further research is needed on risk assessment frameworks, long-term ecological effects, and effective policy implementation, particularly in under-studied regions such as parts of Asia and Africa.

Methodology

Experiment

While studying about emerging contaminants I had done certain experiments like Checking the potability of water and turbidity.With the help of these test it was checked whether the water is potable of drinking or not. The water sample was taken from Pavna dam.

The test had performed to check the presence of coliforms in the water. After inoculation of dam water into Brilliant green lactose bile broth (BGLBB) the turbidity and gas production was observed in the sample. The isolation was done on Endo and Eosin methylene blue(EMB).After incubation, pink colour colonies were observed with metallic sheen on EMB which concluded the presence of coliforms.



Positive tubes of BGLBB, i.e., production of gas and turbidity

Research Design

This study adopts a descriptive and review-based research design to investigate the occurrence, environmental risks, and management of emerging contaminants. The research is based on the analysis of existing scientific literature rather than laboratory experiments or field sampling. This approach is suitable for understanding current trends, challenges, and solutions related to emerging contaminants in 2026.

Data Collection

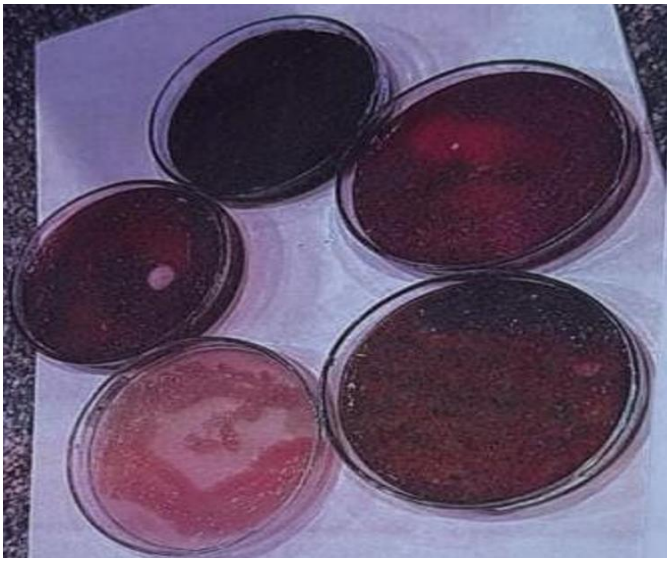
Data for this study were collected from secondary sources, including:

- Peer-reviewed journal articles
- Review papers
- Government and environmental agency reports
- Books and conference proceedings

Relevant literature published mainly between 2015 and 2026 was selected to ensure up-to-date information. Online academic databases such as Google Scholar, ScienceDirect, Springer, and PubMed were used to obtain research articles related to emerging contaminants.

Keywords used for literature search included:

- "Emerging contaminants"
- "Environmental occurrence of emerging pollutants"
- "Environmental risks of contaminants"
- "Management of emerging contaminants"
- "Wastewater treatment and emerging pollutants"



Selection Criteria

The literature was selected based on the following criteria:

- Studies focusing on the occurrence of emerging contaminants in water, soil, or wastewater
- Research discussing environmental or health risks associated with emerging contaminants
- Articles describing monitoring, treatment, or management strategies
- Publications written in English and available in full text

Studies not directly related to environmental aspects or lacking sufficient data were excluded.

Data Analysis

The collected literature was carefully reviewed and analyzed to identify:

- Common types and sources of emerging contaminants
- Environmental compartments where contaminants are frequently detected
- Reported risks to ecosystems and human health
- Existing treatment and management approaches
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The information was then organized into themes such as occurrence, risk assessment, and management strategies. Trends over time were identified and presented using tables, flowcharts, and graphical representations to show increasing contaminant levels across years.

Results

Occurrence of Emerging Contaminants

The review of recent literature indicates that emerging contaminants are widely present in different environmental compartments. Studies published between 2015 and 2026 report the frequent detection of pharmaceuticals, microplastics, PFAS, and pesticides in surface water, groundwater, wastewater, and soil. Among these, pharmaceuticals and microplastics were the most commonly reported contaminants in aquatic environments.

Wastewater treatment plants were identified as major pathways for the release of emerging contaminants into natural water bodies. Many studies reported that conventional treatment systems are not fully effective in removing these contaminants, resulting in their continuous discharge into rivers and lakes.

Trends in Contaminant Levels Over Time

Analysis of data from multiple studies shows a steady increase in the concentration of emerging contaminants over the years. Graphical representations indicate that from 2016 to 2026:

- Pharmaceutical residues showed a gradual but consistent increase in concentration.
- Microplastics displayed a sharp rise, especially after 2020.
- PFAS concentrations increased steadily due to their persistent nature.

These trends suggest that increased chemical usage, urbanization, and population growth have contributed to rising contamination levels.

Environmental and Health Risks

The reviewed literature highlights several environmental risks associated with emerging contaminants. Many studies reported toxic effects on aquatic organisms, including reduced growth, reproductive issues, and behavioral changes. Endocrine-disrupting chemicals were found to interfere with hormonal systems even at low concentrations.

Microplastics were reported to act as carriers for other toxic substances, increasing their harmful effects. PFAS were identified as persistent contaminants with the ability to bioaccumulate, raising concerns about long-term exposure risks to both wildlife and humans.

Effectiveness of Management and Treatment Strategies

Results from reviewed studies show that advanced treatment technologies such as membrane filtration, adsorption using activated carbon, and advanced oxidation processes are more effective in removing emerging contaminants compared to conventional methods. However, these technologies are not widely implemented due to high costs and technical limitations. Several studies emphasized the importance of source control, improved waste management practices, and updated regulatory frameworks. Monitoring programs were found to be limited in many regions, indicating a need for better environmental surveillance systems.

Conclusion

This study investigated the occurrence, environmental risks, and management of emerging contaminants in the environment in 2026, based on a review of recent literature. Emerging contaminants, including pharmaceuticals, microplastics, PFAS, pesticides, and personal care products, are now widely detected in water, soil, and wastewater. The research shows that their concentrations have increased over time, largely due to industrialization, urbanization, agricultural activities, and the limitations of conventional wastewater treatment systems. The findings highlight that emerging contaminants pose significant environmental and health risks, including toxicity to aquatic organisms, endocrine disruption, bioaccumulation, and the potential development of antibiotic resistance. Microplastics and PFAS are particularly concerning because of their persistence and ability to travel long distances in ecosystems. Current management strategies, such as conventional wastewater treatment, are often insufficient to completely remove these contaminants. Advanced treatment technologies like membrane filtration, adsorption, and advanced oxidation processes show higher efficiency but are not yet widely implemented. Additionally, effective management requires source control, proper waste disposal, regulatory policies, and regular monitoring programs.

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RAW conceived the concept, wrote and approved the manuscript.

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