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การปนเปื้อนของไมโครพลาสติกในสิ่งแวดล้อมและผลกระทบต่อสุขภาพของมนุษย์
Microplastics Contamination in an Environment and its Effects on Human Health

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บทคัดย่อ

การปนเปื้อนของไมโครพลาสติกได้กลายเป็นปัญหาระดับโลกที่สำคัญ โดยมีการแพร่กระจายอย่างกว้างขวางในสิ่งแวดล้อมทางทะเล น้ำจืด พื้นดิน และอากาศ งานทบทวนนี้ได้รวบรวมงานวิจัยเกี่ยวกับแหล่งกำเนิดการกระจายตัวในสิ่งแวดล้อมและความเสี่ยงต่อสุขภาพจากไมโครพลาสติก โดยเฉพาะในประเทศไทย ซึ่งพบไมโครพลาสติกในแหล่งน้ำ ตะกอน และอาหารทะเล โดยเส้นใยพลาสติกเป็นรูปแบบที่พบได้บ่อยที่สุด ไมโครพลาสติกที่เกิดจากผลิตภัณฑ์พลาสติกต้นทางและการสลายตัวของขยะพลาสติกขนาดใหญ่สามารถพาเคมีพิษและสะสมในห่วงโซ่อาหาร ซึ่งเป็นอันตรายต่อทั้งระบบนิเวศและสุขภาพมนุษย์ การสัมผัสกับไมโครพลาสติกในมนุษย์เกิดขึ้นจากการกลืน การสูดดม และการสัมผัสทางผิวหนัง ถึงแม้ว่าส่งผลกระทบต่อสุขภาพในระยะยาว ยังคงอยู่ระหว่างการศึกษาแต่หลักฐานเบื้องต้นแสดงให้เห็นถึงความเสี่ยงต่อการเกิดโทษต่างๆ ต่อร่างกาย เช่น การรบกวนฮอร์โมน การเกิดปฏิกิริยาออกซิเดชัน และการอักเสบทั่วร่างกาย การประสานงานระหว่างการวิจัย นโยบาย และการสร้างความตระหนักรู้ เพื่อบรรเทาการปนเปื้อนและปกป้องสุขภาพของทั้งสิ่งแวดล้อม และมนุษย์อาจนำไปสู่แนวทางการแก้ปัญหาได้

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Abstract

Microplastic contamination has emerged as a significant global issue, with widespread presence across marine, freshwater, terrestrial, and atmospheric environments. This review synthesizes current research on sources, environmental distribution, and potential health risks of microplastics, with a particular focus on studies conducted in Thailand. Microplastics originate from both primary products and degradation of larger plastic waste, which can contain toxic chemicals and accumulate in food chains, posing risks to ecosystems and human health. In Thailand, high concentration of the microplastic contamination has been detected in water bodies, sediments, and seafood, fibers being the most common form. Human exposure generally occurs via ingestion, inhalation, and dermal contact, and although long-term health impacts remain under investigation, preliminary evidence suggests risks such as hormonal disruption, oxidative stress, and systemic inflammation. To mitigate/ solve the problem, there is a requirement in coordinating in elements of research, policies, and public awareness.

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Introduction

Plastic pollution has emerged as a critical global environmental and public health issue with significant consequences across ecosystems and human societies [(1)]. Plastic-synthetic or semi-synthetic materials derived from the polymerization of organic compounds-has become integral to modern life. There are widespread applications in both household and industrial sectors. However, the massive and continuous production of plastics has resulted in an alarming accumulation of plastic waste, contributing to environmental contamination in various forms, including large fragments, microplastics, and nanoplastics[(2)].

There are many types of plastic, each with specific uses and properties. These include polypropylene (PP), used in food packaging and toys; polyurethane (PUR), used in foams and cushions; polyethylene terephthalate (PET), commonly found in water bottles; polyvinyl chloride (PVC), used in pipes and construction materials; polystyrene (PS), found in foam containers; and polyethylene, both high-density (HDPE) and low-density (LDPE), used in plastic bags and films. While these materials serve diverse functions, they all share a common trait; when exposed to environmental factors such as sunlight, heat, and physical wear, they degrade into microplastics (less than 5 mm) and potentially further into nanoplastics (less than 100 nm)[(2)].

Plastic materials have become inseparable from our daily lives-ranging from synthetic textiles in clothing (e.g., polyester and nylon), vehicle tires, food packaging, and personal care products, to agricultural applications such as synthetic-coated fertilizers. Despite their durability and utility, plastic materials are now known to pose a significant environmental threat due to their persistence and fragmentation into micro- and nano-plastics over time[(2,3)].

The contamination of microplastics is now widespread, with particles found in the air, drinking water, soil, and food, including meat, seafood, and its products[(2,3)]. As microplastics continue to break down into even smaller particles, their ability in infiltrating biological systems increases. These particles can enter the human body through several major pathways: ingestion of contaminated food and water, inhalation of airborne particles, and dermal exposure via cosmetics and personal care products. Although the long-term health implications remain under active investigation, most studies have associated microplastic exposure with inflammation, immune system disruption, endocrine interference, and potential impacts on organ function[(3,4,5)].

Recent discoveries have heightened global concern, with studies detecting microplastics in human blood, lungs, placenta, and even breast milk, as well as in the blood of newborn infants[(6,7,8,9)]. These findings indicate that microplastics can cross physiological barriers and may accumulate in critical tissues, posing particular risks to vulnerable populations such as pregnant women, fetuses, and young children during early stages of development. To disseminate accurate and update information about microplastics-including its sources, contamination pathways and potential human health impacts-in order to raise widespread awareness among academics, policymakers, and the general public.

Literature Review

This study employed a literature review approach to gather and synthesize current knowledge on microplastic contamination and its impacts on human health. Scientific articles, government reports, and academic theses published between 2015 and 2024 were retrieved from databases such as PubMed, ScienceDirect, Google Scholar, and Scopus. Search terms included *"microplastics," "human health," "environmental contamination,"* and *"Thailand."* Inclusion criteria focused on studies addressing microplastic presence in environmental media (air, water, soil, food), biological accumulation in organisms, and potential health effects. Particular emphasis was placed on research conducted in Thailand.

Relevant data were analysed and organised thematically into sources and types of microplastics, environmental contamination routes, biological impacts, and human health risks. Key findings from studies were summarized in tables to highlight the extent of contamination and regional concerns.

From Plastic Waste to Microplastics

Plastic Waste

Plastic waste refers to discarded plastic products-synthetic materials that are highly resistant to biodegradation. Depending on the type, plastics can take decades to centuries to decompose, resulting in the persistent accumulation of plastic debris in the environment.

The Growing Problem of Plastic Waste

Plastic plays an essential role in modern life, but its widespread use has led to a rapid and ongoing increase in global production. In 2018 alone, more than 330 million tons of plastic were produced globally. It is estimated that over nine billion metric tons have been produced. A significant concern is the vast amount of plastic waste entering the oceans each year, causing serious harm to marine ecosystems. According to the Marine Knowledge Hub, Thailand ranks as the sixth highest contributor of mismanaged plastic waste entering the ocean Figure 1[10].

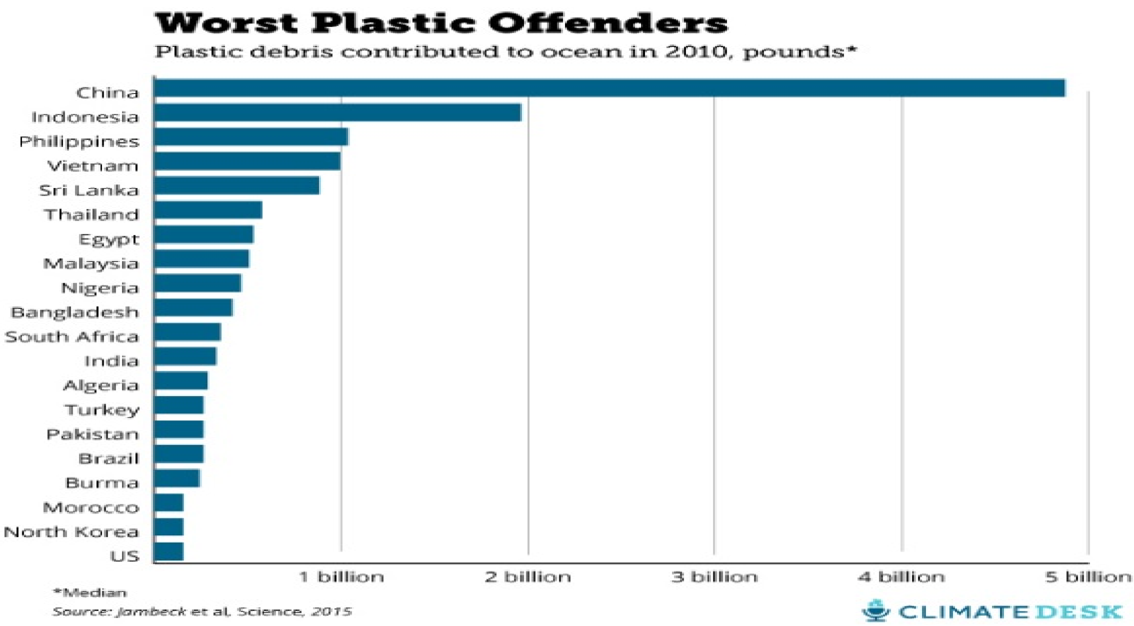

Figure 1 Ranking of Countries by Mismanaged Plastic Waste Entering the Ocean[10]

Microplastics

Microplastics are small plastic particles measuring between one micrometre (μm) and five millimetres (mm) in size[10]. These particles can vary in shape and chemical composition, depending on the plastic materials from which they are derived. Microplastics are now pervasive across the environment and have been detected in diverse ecosystems, including oceans[11], freshwater bodies[12], soils[13], and even in the atmosphere[14]. Their widespread presence is largely attributed to the durability and persistence of plastic materials, which break down slowly over time.

Because of their extremely small size and large surface area, microplastics have a high capacity to adsorb environmental contaminants such as pharmaceutical residues, heavy metals, and harmful microorganisms. This ability enables microplastics to act as vectors for transporting toxic substances into the food chain. As microplastics accumulate in living organisms, they can disrupt ecological balance and biodiversity. Moreover, their presence in seafood and other food sources raises concerns about potential health risks to humans. The contamination also impacts key economic sectors, such as the fishing and tourism industries, by damaging marine life and reducing the aesthetic and recreational value of natural environments.

In addition to microplastics, other plastic particles are classified based on size. Macroplastics are larger than one centimeter, mesoplastics range from one to ten millimeters, and nanoplastics range from one to thousand nanometers. Among these, nanoplastics are particularly concerning due to their extremely small size, which enables them to penetrate biological membranes and accumulate in cells and tissues. This can result in adverse effects at the cellular and molecular levels, although the full extent of these impacts is still under investigation.

Contamination of microplastics into the environment

Microplastics can enter the environment through several pathways, depending on their source and characteristics. One major route is through everyday consumer products. Primary microplastics, such as micro-beads used in cosmetics, skincare, and cleaning products, are typically washed down household drains and pass-through wastewater treatment systems, eventually entering natural water sources. Additionally, synthetic fibers from clothing released during laundry contribute significantly to microplastic pollution in wastewater.

Improper waste disposal is another major contributor. Large plastic items, when discarded, irresponsibly, degrade into smaller fragments over time due to environmental exposure. These secondary microplastics can be transported by wind or rain into rivers, oceans, or poorly managed landfills, leading to contamination of soil, groundwater, and surface water bodies. The persistence of these particles in the environment poses long-term risks.

Industrial activities also play a role in the release of microplastics. During the manufacturing and transport of plastic materials, such as resin pellets, accidental spillage can occur. Furthermore, microplastics are generated during various human activities including fishing, maritime transport, and vehicular traffic, particularly from the abrasion of car tires.

These sources continuously contribute to the accumulation of microplastics in both terrestrial and aquatic environments.

Microplastic Contamination in Thailand

Thailand faces growing challenges in managing plastic waste, which has led to increasing levels of microplastic contamination in various environmental compartments. Due to inadequate waste disposal, rapid urbanization, and heavy reliance on plastic products, microplastics have been detected across marine ecosystems, freshwater bodies, sediments, and aquatic organisms throughout the country. These findings highlight the urgent need for localized data to better understand the extent of contamination and to inform targeted environmental and public health policies.

To support this, numerous studies have been conducted to assess microplastic presence in different regions and sample types across Thailand. Table 1 summarizes selected research findings, illustrating the scale, distribution, and types of microplastic contamination observed in both coastal and inland environments.

Table 1 Examples of Research Studies on Microplastic Contamination in Thailand

Location/Study Area	Key Findings
Chaolao & Kungwiman Beaches, Chanthaburi	Microplastics found in Danax sp. and Paphia sp., mostly fibers and black in color. Tharamon et al. (2016)[15]
Eastern Coast (Angsila, Bangsaen, Samaesarn)	Sessile invertebrates show 0.2-0.6 particles/g; higher accumulation in filter feeders. Thushari et al. (2017)[16]
Lower Gulf of Thailand (Commercial Fishes)	66.7% of fish had ingested plastics, majority were microplastics (<5 mm), mostly fibers. Azad et al. (2018a)[17]
Lower Gulf of Thailand (Fish Ingestion Study)	54.3% of fish had ingested plastics; demersal fish had slightly higher microplastic load. Azad et al. (2018)[18]
Phuket West Coast Beaches	Highest microplastic debris at Patong beach; fibers and formless particles common. Ekchit & Ruamkaew (2019)[19]
Andaman Sea Coast	Majority of medium and small particles were polyester fibers; large were PS. Chetsukchai et al. (2019)[20]
Sediment Beaches, Lower Gulf of Thailand	Higher contamination in dry season; PET, PP, PE, and polyester dominant types. Kreekrinuch et al. (2019)[21]
Bueng Boraphet Wetland, Nakhon Sawan	Microplastics higher during dry season; black and red fibers most common. Neatsingsang (2020)[22]
Fishery Wharf Market, Chonburi	Gastropods and bivalves contaminated with fibers and fragments, mostly black. Sealee (2020)[23]
Beach Sediments, Phuket Coast	Majority were black fibers; PET, PS, and PP most common polymers. Thongnonghin (2021)[24]

Table 1 Examples of Research Studies on Microplastic Contamination in Thailand (continue)

Location/Study Area	Key Findings
Map Ta Phut Industrial Estate, Rayong	Low contamination in crabs, mostly blue fibers; relatively lower than other countries. Fangsrikum et al. (2021)[25]
Khlong Tho, Ayutthaya	Surface water showed high microplastic levels, especially fibers and fragments. Ong-oard & Tantipanatip (2021)[26]
Lower Chao Phraya River	Samut Prakan and Nonthaburi showed highest levels in water and sediment respectively. Jendanklang et al. (2023)[27]
Phong River, Northeast Thailand	Higher contamination in rainy season; PP and PE were most common polymers. Doungmontri et al. (2024)[28]
Phetchaburi River	Highest microplastic levels in aquaculture/fishery areas; strong correlation with water quality. Na Songkla et al. (2024)[29]

Human Health Impacts of Microplastics

Microplastics represent a silent but growing threat to human health. Emerging research suggests that humans are increasingly exposed to and accumulating microplastics in the body through various pathways, including ingestion, inhalation, and dermal contact. Over time, the buildup of microplastics may disrupt internal biological systems and contribute to serious health issues. If exposure reaches excessive levels, microplastics could lead to life-threatening conditions. The following are key health concerns associated with microplastic exposure.

Hormonal disruption

Microplastics often contain additives such as Bisphenol A (BPA), a known endocrine-disrupting chemical. BPA can interfere with hormone signaling, particularly affecting male reproductive hormones. This disruption has been linked to reduced sexual desire and erectile dysfunction in some cases[30].

Blood vessel function disruption

Due to their small size-comparable to that of bacteria-microplastics can potentially circulate in the bloodstream. When present in large quantities, they may obstruct blood flow and interfere with vascular function[31].

Neurological effects

Repeated exposure to BPA and other plastic additives has been shown to affect the nervous system, especially in children. Research indicates that early and chronic exposure may impair neurological development and reduce the brain’s functional capacity[32].

Increased cancer risk

Long-term accumulation of microplastics in human tissues may increase cancer risk. These particles can embed themselves in organs and continuously release toxins, including heavy metals. Over time, this may lead to cellular damage and increase the likelihood of cancer development[31].

Toxin accumulation and transport

Microplastics have a high capacity to absorb and retain environmental pollutants. These particles can collect harmful substances such as persistent organic pollutants and heavy metals, transporting them from marine environments into the human body through the food chain[33].

Table 2 Studying the Impacts of Microplastics on Human Health

Examination	Background
Wang et al. (2023)[34]	Investigated the effects of polystyrene microplastics on mice, revealing that these particles can cross the blood-brain barrier, activate immune cells (microglia), and potentially induce neurotoxicity.
Leslie et al. (2022)[35]	Developed a method to detect plastic particles in human blood and found microplastics present in healthy volunteers, suggesting potential systemic distribution throughout the body.
Zhang et al. (2021)[36]	Detected microplastics in the placenta and first stool (meconium) of newborns in Shanghai, indicating fetal exposure and potential developmental concerns.
Lee et al. (2019)[37]	Reviewed in vitro studies on human cells exposed to microplastics, noting impacts such as oxidative stress, cytotoxicity, and disruption of gene expression.
Van Cauwenberghe et al. (2015)[38]	Assessed microplastic contamination in seafood globally and highlighted the associated health risks for humans consuming contaminated marine organisms.
Rochman et al. (2015)[39]	Reviewed ecotoxicological effects of microplastics on aquatic organisms, including physical harm and chemical exposure, which may mirror potential mechanisms of harm in humans.

Findings

The findings of this review highlight the pervasive nature of microplastic contamination across environmental media; including water, soil, air, and biota, and the growing concern over its potential health impacts on humans. Microplastics, originating from both primary and secondary sources, are now commonly detected in food, drinking water, and even human biological samples such as blood, placenta, and breast milk. This wide distribution underscores the urgency of addressing microplastic pollution not only as an environmental issue but also as a public health threat.

Evidence from Thailand and global studies indicates that aquatic environments, especially marine and coastal ecosystems, are major sinks for microplastics. Thai studies reviewed show significant contamination levels in fish, bivalves, sediment, and surface water, reinforcing the idea that seafood consumption may be a key exposure route for humans.

The dominance of microplastic fibers in most samples suggests a strong link to household wastewater and textile industries. Moreover, seasonal variations in contamination, often higher in dry seasons, highlight the influence of weather patterns and human activity on microplastic dispersion.

From a health perspective, although research is still evolving, there is growing concern about the physiological impacts of chronic microplastic exposure. In vitro and animal studies suggest potential effects such as oxidative stress, inflammation, endocrine disruption, and interference with neurological development. While the extent of human health risks remains to be fully understood, the detection of microplastics in critical organs and fluids (e.g., blood and placenta) indicates the potential for systemic exposure, especially among vulnerable populations such as infants and pregnant women.

Despite the growing body of research, this review identifies several gaps. First, there is a lack of standardized methods for sampling, detecting, and quantifying microplastics, particularly in biological samples. Secondly, long-term epidemiological studies assessing the health outcomes of chronic exposure are still lacking. Most current health-related findings are based on animal models or laboratory conditions, which may not fully reflect real-world human exposures. Finally, there is a need for interdisciplinary collaboration between environmental scientists, toxicologists, clinicians, and policymakers to address the complex pathways through which microplastics interact with human systems.

Importantly, while this review summarizes the scale and risks of microplastic contamination, it also underscores the need for preventive action. Raising public awareness, reducing plastic consumption, and improving waste management practices are immediate steps. Additionally, Thailand should prioritize investment in wastewater treatment infrastructure and adopt strong regulations on industrial plastic emissions. At the international level, coordinated research and policy frameworks. This is similar to those addressing climate change or chemical pollutants which are essential to manage microplastic risks, effectively.

Discussion

Critical Analysis

While this review provides a comprehensive overview of microplastic contamination and its potential health impacts, several limitations and gaps in current research should be acknowledged. Firstly, much of the evidence regarding human health effects is derived from in vitro studies or animal models, which may not fully translate to real-world human exposures. There is a lack of long-term epidemiological data examining microplastics in relation to chronic diseases or physiological dysfunctions in humans. Without this, causality remains speculative, and the biological significance of microplastic presence in tissues such as blood or placenta is not yet fully understood.

Additionally, the reviewed studies-both globally and within Thailand-often employ different sampling methods, particle size ranges, and detection techniques, making cross-study comparisons difficult. The absence of standardized protocols limits the ability to assess trends or conduct meta-analyses. In Thailand, while localized research has increased, many studies focus on marine environments and seafood contamination, with relatively less attention given to freshwater systems, air pollution, or land-based exposure pathways such as agriculture and drinking water.

Furthermore, there is limited data on nanoplastics, which are potentially more harmful due to their abilities to penetrate cell membranes and interact with biological systems at the molecular level. Current detection technologies are insufficiently; sensitive to quantify nanoplastics reliably, representing a major knowledge gap.

Lastly, while this review identifies key pathways of contamination and exposure, it could further explore socio-economic and behavioral dimensions-such as plastic consumption patterns, public awareness, and policy enforcement, particularly within the Thai context.

In summary, while the existing evidence emphasize the urgency of addressing microplastic pollution, more interdisciplinary research is required to address definitive information on human health impacts and to develop effective mitigation strategies.

Conclusion

Microplastic contamination poses an increasing threat to both environmental and human health. In Thailand and worldwide, microplastics have been detected in air, water, soil, and various organisms, including humans. While the full extent of health effects remains under investigation, early evidence points to risks such as hormonal disruption, inflammation, and potential toxicity. The persistent nature of microplastics and their presences in the food chain highlight the urgent need for preventive action.

Recommendations

To address this issue, public awareness must be strengthened to reduce plastic use and promote sustainable alternatives. Waste management systems should be improved, particularly in wastewater treatment and plastic recycling. Strong regulations are required for preventing emissions of microplastic from industry and consumer products. Meanwhile, ongoing research should focus on standardizing detection methods and assessing long-term health impacts. A coordinated approach involving government, academia, industry, and communities is essential to mitigate microplastic pollution and protect public health.

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