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MICROPLASTICS IN GASTROPOD MOLLUSCS: A REVIEW OF CONTAMINATION TRENDS IN GLOBAL STUDIES

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ABSTRACT: Microplastics (MPs) have become a global concern due to their persistence in the environment and their harmful effects on ecosystems, infrastructure, society, and the economy, warranting immediate attention and action. Ecotoxicological impacts of MPs are significant, as they tend to infiltrate food chains, facilitating the trophic transfer of MPs and associated contaminants, and potentially endangering human health. The isolation and characterisation of MPs can be improved, enabling science to elucidate their fate in organisms. Molluscs are among the major groups affected by MP contamination, which can serve as vectors for the biomagnification of pollutants within aquatic food webs. This review demonstrates the global distribution, types, and chemical nature of MP contamination in molluscs. It summarises the different types of MPs reported from various molluscan species and compiles a detailed review table based on existing studies. Current research indicates that gastropods inhabiting diverse aquatic ecosystems, including freshwater, mangrove, marine, coastal, estuarine, brackish water, and semi-enclosed marine environments, are under threat of MP contamination. Studies also show that mangrove ecosystems appear to be the most heavily affected, with gastropods showing a high number of MP particles per individual. Fibres and fragments are the most commonly detected forms of MPs in gastropods, and smaller particles are more frequently ingested due to their size. A trend was observed in both MP contamination level and MP abundance, with larger gastropod species exhibiting higher MP loads than smaller species. The widespread presence of MPs in gastropod molluscs raises serious ecological concerns and highlights potential risks of human exposure through trophic transfer in the food chain. Hence, this review helps clarify contamination levels and highlights the importance of further research and management to control MP pollution.

KEYWORDS: bioaccumulation; contamination; gastropods; microplastics

MICROPLASTICS: AN INTRODUCTION

Plastics are synthetic polymers that persist in the environment and do not readily break down. The amount of plastic garbage in the environment is a major concern since it may have a negative impact on humans, wildlife, and their environments. About 10% of household waste consists of plastics, and they are largely discarded in landfills (VERMA et al. 2016). Significant environmental contamination has resulted from their discharge into the environment (ANUNOBI 2022, NAPPER & THOMPSON 2023). The groundwater and nearby water bodies were also contaminated by the toxic chemicals released from chlorinated plastic into soil, which may lead to severe ecological impact on water-dependent species (PROSHAD et al. 2018, BORRELLE et al. 2020).

Plastic debris in the environment can be classified into different categories based on size: nanoplastics, microplastics, mesoplastics, macroplastics and megaplastics (GALL & THOMPSON 2015, HAMD et al. 2022, LIU et al. 2025). The term Microplastics (MPs) was introduced by THOMPSON et al. (2004) to define plastic fragments less than 5 mm in diameter. MPs occur in various forms, including pellets, fibres, films, granules, and foams. MPs are categorised into

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two main types based on their origin: primary and secondary microplastics. Primary microplastics are intentionally manufactured tiny plastic or resin particles used in cosmetics, personal care items, and industrial materials, etc. They often enter aquatic ecosystems through rivers, wastewater treatment plants, and similar discharge routes (Vandermeersch et al. 2015, Laskar & Kumar 2019). Secondary microplastics arise when larger plastic items break down over time due to physical forces like sunlight, waves, and wind, or through biological processes such as microbial activity, transforming bigger plastics into smaller fragments (Rochman et al. 2015, Lau et al. 2020, Bermúdez & Swarzenski 2021).

Microplastics can be classified by their chemical composition, such as polyethylene, polystyrene, polypropylene, polyamide, and polyvinyl chloride microplastics (Zhang et al. 2018, Yan et al. 2019, Liu & Zheng 2025). MP pollution in aquatic ecosystems has risen due to the extensive accumulation of plastics, improper waste management, and the easy spread of MPs through water bodies (Rillig et al. 2017). MPs are distributed in the water according to their density, with low-density polymers such as polyethylene and polypropylene remaining at the surface, whereas high-density plastics, including polyvinyl chloride, polystyrene, polyamide, and polyethylene terephthalate, will move to deeper layers (Kumar et al. 2021). Biofouling can also enhance MPs sinking (Kaiser et al. 2017). As a result, organisms in different trophic levels and feeding habits, including predators, omnivores, and filter feeders, are exposed to MPs (Guo & Wang 2019). Recent studies show that critical levels of MP contamination were found in sensitive ecosystems such as estuaries, mangroves and lakes along the Kerala coast, India (Pitchaimani et al. 2025).

MPs in the atmosphere come from various sources like fibres from synthetic textiles, microplastic-contaminated dust, tyre wear during transportation, emissions from waste incineration, industrial processes, and suspended particles from landfills (Galgani et al. 2022, Liu & Zheng 2025). MPs may migrate through aquatic ecosystems via urban runoff, sewage treatment plants, and marine industries, which significantly contribute to water pollution in rivers and lakes (Liu & Zheng 2025). MPs have been detected in marine species such as zooplankton (Cole et al. 2013), fish (Lusher et al., 2013), as well as terrestrial animals like earthworms (Rillig et al. 2017) and plants such as maize (Sun et al. 2021).

Over the past few years, research has examined MPs in various marine molluscs, including commercially harvested, wild, and aquaculture bivalves such as mussels, oysters, and clams. Nonetheless, there have been limited surveys that adequately cover MP contamination in gastropod molluscs. A few studies demonstrate connections between MPs in water/sediment and molluscs (Prarat et al. 2024). Gastropods have also been increasingly studied as bioindicators in recent years (Thushari et al. 2017, Aranda et al. 2022, Curren et al. 2024). A primary reason is that gastropods have a global distribution; they are found in intertidal and marine sediments, making them ideal organisms for MPs monitoring. Secondly, they are known to tolerate a wide range of environmental stresses like anoxia, temperature (Storey & Storey 2017), salinity (Ho et al. 2019), and desiccation (Schweizer et al. 2019, Curren et al. 2024). Thirdly, they exhibit diverse feeding strategies; many are detritus feeders that feed directly on sediments, while others are grazers, herbivores, carnivores, and scavengers (Declerck 1995, Curren et al. 2024). Many gastropods also tend to feed on biofilms, assimilating both algal and detritus-based carbon (Wu et al. 2017).

Considering the gastropods, because of their diverse feeding strategies, these organisms are highly vulnerable to the contamination of MPs (Gheoca et al. 2021, Yona et al. 2023). Microplastics can enter organisms through direct consumption or indirect consumption through the food chain and have been found in many gastropod species across marine, freshwater and land-based ecosystems (Kühn et al. 2020, Santos et al. 2021, Curren et al. 2024). Direct consumption occurs through their grazing behaviour, which needs mucus production for locomotion and for attaching to substrates (Curren et al. 2024). Gastropods have sticky pedal mucus, which helps in MPs uptake (Gutow et al. 2019). Gill respiration also results in MPs accumulation (Xu et al. 2020). The route of MPs intake in carnivorous gastropods is by ingesting contaminated prey (Xu et al. 2022). Deposit-feeding and grazing benthic organisms feeding in sediment-rich intertidal and subtidal zones may ingest MPs directly through sediment and associated biofilms, as feeding mode influences MPs uptake and accumulation in benthic gastropod fauna (Hiki & Nakajima 2022, Musrin et al. 2025). MPs are ingested by gastropods because of their small size and biofilm-coated surfaces that resemble natural food particles (Musrin et al. 2025).

METHODOLOGY OF THE REVIEW

This review was conducted during the period of six months from December 2025 to May 2026, following the principles of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-

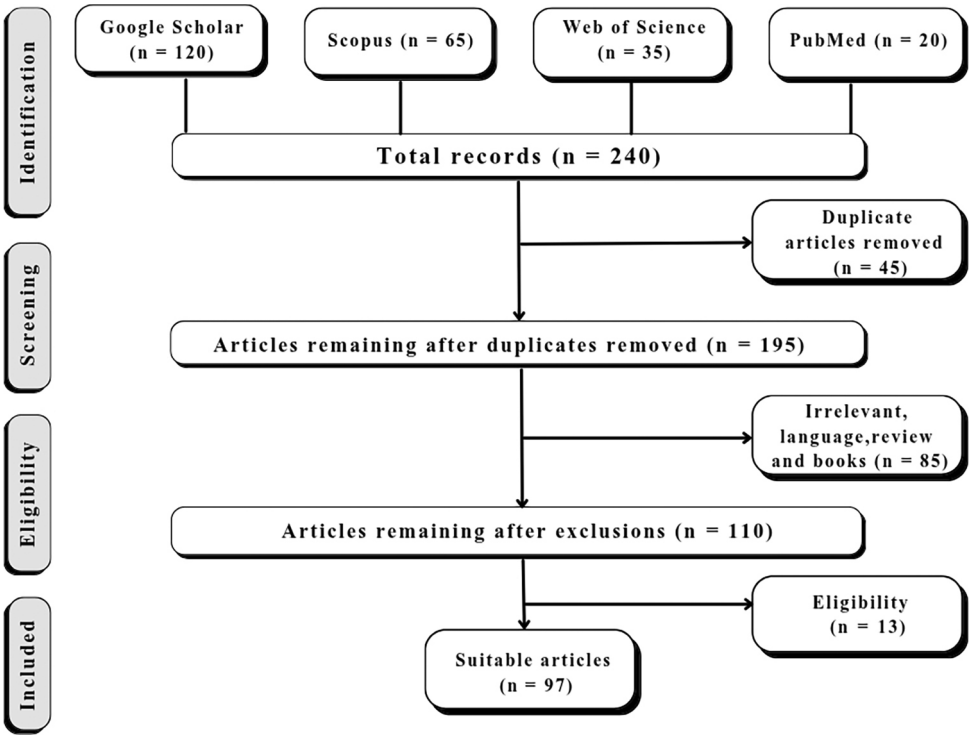

Fig. 1. Simplified flow diagram of the article selection process following PRISMA Guidelines

Analyses) framework. A systematic search was performed in Google Scholar, Scopus, Web of Science, and PubMed, using combinations of the following descriptors: "microplastics," "gastropod," "mollusc," "contamination," "bioaccumulation "trophic transfer," "ecotoxicology," and "feeding habit".

A total of 240 publications were initially identified from Google Scholar, Scopus, Web of Science, and PubMed. After removing the 45 duplicate articles, 195 records were screened based on title and abstract, and 85 records were excluded. 110 articles were eligible for full-text assessment, and finally, 13 articles were excluded from the list as they did not satisfy the inclusion criteria. Ultimately, 97 studies that met all the eligibility requirements were included in the review.

Inclusion criteria were:

1. Studies examining the research topic, MP contamination in gastropod molluscs, degradation, fragmentation, or transformation within gastropods, trophic transfer, and ecotoxicology.
2. Original experimental or observational research articles.
3. Peer-reviewed publications available in English.

The exclusion criteria included:

1. Duplicate records.
2. Articles unrelated to the research objectives.
3. Review articles, books, conference abstracts, and non-peer-reviewed publications.
4. Studies that did not satisfy the eligibility criteria after full-text assessment.

The screening procedure includes three steps: identification, eligibility and inclusion (Fig. 1). Using the selected 97 eligible articles, we have prepared a detailed review on MP contamination in gastropod molluscs.

Abbreviations for MPs: EVA – Ethylene-vinyl acetate; HDPE – High-density polyethylene; LDPE – Low-density polyethylene; PA – Polyamide; PE – Polyethylene; PET – Polyethylene terephthalate; PP – Polypropylene; PVA – Poly(vinyl acetate); PVC – Polyvinyl chloride; PS – Polystyrene; PU – Polyurethane.

OCCURRENCE AND CHARACTERISTICS OF MICROPLASTICS IN GASTROPODS

Microplastic contamination in gastropods has been documented across a wide range of aquatic ecosystems, and the results showed active plastic pollution in benthic gastropod molluscs (Hodkinson & Jackson 2005, Fitri & Patria 2019, Akindele et al. 2019, Ojeda et al. 2021, Zhao et al. 2024, Curren et al. 2024). A total of 41 gastropod species were investigated worldwide for MP contamination, and these species are from different environmental ecosystems such as freshwater, marine, mangrove, and brackish ecosystems (Table 1; Fig. 2). Among these, the freshwater ecosystem had the highest study re-

Table 1. Review table showing microplastic (MP) contamination reported worldwide from gastropod fauna

	Gastropod species	Common name	Location and type of ecosystem	Analytical method used	Tissue type	Feeding habits	Main food source	MP morphotype/polymer type	References
1	*Cerithidea obtuse* (Lamarck, 1822)	Obtuse Horn Shell	Tanjung Jabung Barat District, Jambi, Indonesia (Mangrove Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Detritivore/ Grazer	Detritus, microalgae, biofilm	Fibers, films, and fragments were present	FITRI & PATRIA 2019
2	*Lanistes varicus* (O. F. Müller, 1774)	West African Apple Snail	Osun River, Nigeria, Africa (Freshwater Ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore/ Omnivore	Aquatic plants, algae, detritus	Fibres and films were present. MP films were made of polyethylene	AKINDELE et al. 2019
3	*Melanoides tuberculata* (O. F. Müller, 1774)	Red-Rim Melania or Malaysian Trumpet Snail	Osun River, Nigeria, Africa (Freshwater Ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Detritivore/ Grazer	Algae, biofilm, organic detritus	Only fibers were recorded	AKINDELE et al. 2019
4	*Theodoxus fluviatilis* (Linnaeus, 1758)	River Nerite	Rhine River, Europe (Freshwater Ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Grazer	Periphyton, diatoms	Only fibers were recorded. MPs were made of nylon and polypropylene	AKINDELE et al. 2019
5	*Littoraria scabra* (Linnaeus, 1758)	Mangrove Periwinkle	Pramuka Island, Jakarta Bay, Indonesia (Mangrove Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Herbivore	Algae, fungal & mangrove biofilm	Fiber, film, and fragment were recorded. Fiber marked the highest percentage	PATRIA et al. 2020
6	*Buccinum koreanum* (Choe, Yoon et Habe, 1992) (# as *Buccinum koreana*)	True Whelk	Bohai Sea, Tiongkok, China (Semi-enclosed marine ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Scavenger/ Carnivore	Dead animals, worms, molluscs	Fibers, films, and fragments were present	ZHAO et al. 2024
7	*Neverita didyma* (Röding, 1798)	Moon Snail	Bohai Sea, Tiongkok, China (Semi-enclosed marine ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Carnivore	Bivalves and other molluscs	Fibers, fragments, and films were present. Major polymer types are PE, PP, PS, PET, and PA	ZHAO et al. 2024
8	*Neptunea subdilatata* (Yen, 1936) (# as *Siphonalia subdilatata*)	Neptunea	Bohai Sea, Tiongkok, China (Semi-enclosed marine ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Carnivore/ Scavenger	Molluscs, polychaetes, carrion	Fiber and films were present	ZHAO et al. 2024
9	*Rapana venosa* (Valenciennes, 1846)	Veined Rapa Whelk	Bohai Sea, Tiongkok, China (Semi-enclosed marine ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Carnivore	Bivalves (oysters, mussels, clams)	Fibers, fragments, and Film. Polymer types are PE, PP, PS, PET, and PA	ZHAO et al. 2024
10	*Sinotaia aeruginosa* (Reeve, 1863) (# as *Bellamya aeruginosa*)	Chinese Viviparid Snail	Taihu Lake, China (Freshwater Ecosystem)	Microscopy and infrared spectroscopy	Soft tissue (after shell removal)	Omnivore	Algae, detritus, plant material	Polymers including PVA, PET, PS, and PA	XU et al. 2020

	Gastropod species	Common name	Location and type of ecosystem	Analytical method used	Tissue type	Feeding habits	Main food source	MP morphotype/polymer type	References
11	*Tegula rustica* (Gmelin, 1791) (# as *Chlorostoma rustica*)	*Trochus rusticus*	Bohai Sea, Tiongkok, China (Semi-enclosed marine ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore	Macroalgae, microalgae	Fiber, fragments, and film were present	ZHAO et al. 2024
12	*Nacella magellanica* (Gmelin, 1791)	*Patella magellanica*	Beagle Channel, Argentina (Marine Ecosystem)	Micro-Raman spectroscopy	Soft tissue (after shell removal)	Herbivore	Microalgae, diatoms	Fibres were the most abundant followed by fragments and films. Fibres and films were identified as semi-synthetic cellulose	OJEDA et al. 2021
13	*Nerita balteata* Reeve, 1855 (# as *Nerita articulata*)	Lined Nerite	Tropical estuary in Selangor, Malaysia (Freshwater Ecosystem)	ATR-FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore	Algae and biofilm	Fibres are dominant	ZAKI et al. 2021
14	*Telescopium telescopium* (Linnaeus, 1758)	Telescope Snail	Rambut Island, Jakarta Bay, Indonesia (Mangrove Ecosystem)	Microscopic observation	Soft tissue, respiratory organ, digestive organ	Detritivore	Organic detritus, sediment microbes	Dominant MPs are films	PUTRI & PATRIA 2021
			Situbondo, East Java Province, Indonesia (Mangrove Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Herbivore	Aquatic plants and algae	Fiber, fragment, film, and microbeads were identified, with fibers being dominant	YONA et al. 2023
			Versova Creek, Mumbai, India (Mangrove Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore/ Detritivore	Organic detritus, algae	Fragments predominating. Polyethylene, polypropylene, and polyurethane were the major polymers	DAR et al. 2023
			Pasuruan pond areas, East Java, Indonesia (Mangrove Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore/ Detritivore	Algae, seagrass detritus	Fragments, fibers, films, and pellets were identified. The polymers detected included LDPE, EVA, latex, HDPE, PP, PVC, polycarbonate, and PS	SUPRIATNA et al. 2023
			Versova Creek, Mumbai, India (Mangrove Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore	Seaweeds (mainly red and green algae)	Most MPs were filaments. The polymers identified were PE, PP, and PU	DAR et al. 2023
15	*Pomacea paludosa* (Say, 1829)	Florida Apple Snail	Freshwater ecosytem, Karaikudi area, India	FTIR spectroscopy	Digestive gland tissue/hepatopancreas tissue	Herbivore/ Detritivore	Algae and detritus	Fibers, films, and fragments were present	JEYAVANI et al. 2022

	Gastropod species	Common name	Location and type of ecosystem	Analytical method used	Tissue type	Feeding habits	Main food source	MP morphotype/polymer type	References
16	*Reishia clavigera* (Küster, 1860)	Asian Rock Shell	Kei Ling Ha Hoi, Hong Kong (Mangrove Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Herbivore/ Detritivore	Algae, detritus	Fibres and fragments recorded	XU et al. 2022
17	*Strombus* sp. (Linnaeus, 1758)	True Conch	Bintan Island, Indonesia (Mangrove Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Herbivore	Algae, diatoms	Fibers, films, and fragments were present	KAFIBIHI et al. 2022
18	*Aplysia brasiliana* Rang, 1828	Mottled Sea Hare	Camburi Beach, Vitória, southeastern Brazil (Brackish Water Ecosystem)	Raman spectroscopy	Soft tissue (after shell removal)	Herbivore/ Omnivore	Aquatic plants, algae, detritus, animal matter	Fibers are abundant	SCHUAB et al. 2023
19	*Dolomena turturella* (Röding, 1798) (# as *Laevistrombus turturella*)	*Lambis turitella*	Coastal waters of Singapore (Marine coastal Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Detritivore/ Omnivore	Decaying plants, algae, microorganisms	Fibres and fragments were present. Acrylic, polyamide and polyethylene terephthalate as the major polymer types	CURREN et al. 2024
20	*Filopaludina sumatrensis speciosa* (Deshayes, 1876)	Trapdoor Snail	U-Taphao, southern Thailand (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore/ Detritivore	Algae, organic detritus	Fibers were the most common MPs	JITKAEW et al. 2023
21	*Patella caerulea* (Linnaeus, 1758)	Mediterranean Limpet	Southeastern coast of Turkey (Marine coastal Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Grazer/ Detritivore	Periphyton, algae, detritus	Fibers were the dominant type, followed by fragments. The polymers were PP, PE, PET, and HDPE	YÜCEL & KILIÇ 2023
22	*Pomacea canaliculata* (Lamarck, 1822)	Golden Apple Snail or Channeled Apple Snail	U-Taphao, southern Thailand (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Grazer	Microalgae and biofilm	Fibers, films, and fragments were present	JITKAEW et al. 2023
			Brantas River, East Java, Indonesia (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Grazer/ Detritivore	Microalgae, detritus	Comprising fibers and fragments	ISLAMY et al. 2025
23	*Physella acuta* (Draparnaud, 1805) (# as *Physa acuta*)	Acute Bladder Snail	River Ganga, Patna, Bihar, India (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Grazer/ Detritivore	Crushed fish food	Fibers and films were present. Polymer detected is PS	KUMARI et al. 2023
24	*Filopaludina martensi* (Frauenfeld, 1864)	White Wizard Snail	Mun River, Thailand (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore/ Detritivore	Algae, plant debris	Fibers, films, and fragments were present	LABCOM et al. 2024

	Gastropod species	Common name	Location and type of ecosystem	Analytical method used	Tissue type	Feeding habits	Main food source	MP morphotype/polymer type	References
25	*Mekongia sphaericula* (Deshayes, 1876)	*Paludina sphaericula*	Mun River, Thailand (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore/ Detritivore	Epiphytic algae, detritus	Fibers and films were present	LABCOM et al. 2024
26	*Pseudominolia sulcifera* (A. Adams, 1855) (# as *Pseudominolia biangulosa*)	*Margarita biangulosa*	Eastern Arabian Sea (Marine Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore	Algae, diatoms	Fibres and fragments recorded	NIKHIL et al. 2024
27	*Tesseracme quadrapicalis* (G. B. Sowerby II, 1860)	Quadrapicalis	Eastern Arabian Sea (Marine Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore	Algae and biofilm	Predominant MPs are fibres and fragments	NIKHIL et al. 2024
28	*Babylonia spirata* (Linnaeus, 1758)	Spiral Babylon, Spiral Whelk or Ivory Whelk	Sakthikulangara, Kollam, Kerala, India (Brackish Water Ecosystem)	Micro Raman spectroscopy	Soft tissue (after shell removal)	Herbivore	Microalgae and biofilm	Fibres, primarily comprising PE, PP, PS, LDPA, PA, PES, PVC and PET, were the most dominant forms of MPs	ABISHA et al. 2024
			Indus Delta, Pakistan (Mangrove Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Grazer/ Detritivore	Periphyton, diatoms, detritus	Fiber was dominant followed fragments, films, and microbeads	MOIN et al. 2025
29	*Filopaludina javanica* (von dem Busch, 1844)	Javanese Pond Snail	Brantas River, East Java, Indonesia (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Deposit feeder/Detritivore	Organic detritus, sediment microbes	Cosmetic microbeads and packaging films	ISLAMY et al. 2025
30	*Laevistrombus canarium* (Linnaeus, 1758) (# as *Strombus canarium*)	Dog Conch	Chonburi Province, Thailand (Marine Ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Omnivore	Algae, detritus, aquatic plants	No MPs were recorded	WONG-SOON-THORNCHAI et al. 2025
31	*Littorina littorea* (Linnaeus, 1758)	Common Periwinkle	Saint Martin's Island, Bay of Bengal, Bangladesh (Marine Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Grazer/ Detritivore	Algae, detritus	PP and PE were the major polymer types, followed by PS and polyethylene terephthalate	RAHMAN et al. 2025
32	*Nerita maxima* (Gmelin, 1791)	Giant Nerite	Balekambang Beach, southern Java, Indonesia (Marine Ecosystem)	ATR-FTIR spectroscopy	Soft tissue (after shell removal)	Grazer/ Detritivore	Periphyton, algae	Fragments are dominant in MPs, followed by fibres. Polymer type-polystyrene and nylon	AMANDA et al. 2025

	Gastropod species	Common name	Location and type of ecosystem	Analytical method used	Tissue type	Feeding habits	Main food source	MP morphotype/polymer type	References
33	*Peronina tenera* (Stoliczka, 1869)	Sea Slug	Subarnarekha estuary, Bay of Bengal (Mangrove Ecosystem)	Raman spectroscopy	Soft tissue (after shell removal)	Detritivore	Mangrove leaf litter, detritus, microbes	Fibers, films, and fragments were present	BAR et al. 2025
34	*Potamopyrgus antipodarum* (J. E. Gray, 1843)	New Zealand Mud Snail	Kocabaş Stream, Türkiye (Freshwater Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Detritivore	Detritus	A plastic fibril was identified	ZILIFLI et al. 2025
35	*Rhinoclavis sinensis* (Gmelin, 1791)	Cerithid Snail	Balekambang Beach, southern Java, Indonesia (Marine Ecosystem)	ATR-FTIR spectroscopy	Soft tissue (after shell removal)	Carnivore/ Scavenger	Polychaetes, molluscs, carrion	Fragments are dominant; polymer types are polystyrene and nylon	AMANDA et al. 2025
36	*Sinotaia quadrata* (W. H. Benson, 1842)	Chinese Snail	Provinces of Florence and Prato in the Tuscany Region, Italy (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Detritivore/ Grazer	Detritus, microalgae, biofilm	Fragments and fibers dominant. Polyethylene, and polyethylene terephthalate are the primary polymers	GABETTI et al. 2025
37	*Sulcospira* sp. (Troschel, 1858)	Black Panther Snail	Brantas River, East Java, Indonesia (Freshwater Ecosystem)	Microscopic observation	Soft tissue (after shell removal)	Herbivore/ Omnivore	Aquatic plants, algae, detritus	The predominant MPs fibers	BUWONO et al. 2025
38	*Sulcospira testudinaria* (von dem Busch, 1842)	Black Panther Snail or Susuh Kura Snail	Brantas River, East Java, Indonesia (Freshwater Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Detritivore/ Grazer	Algae, biofilm, organic detritus	Industrial pellets and synthetic microfibers were found	ISLAMY et al. 2025
39	*Terebralia palustris* (Linnaeus, 1767)	Giant Mangrove Whelk	Sea of Oman (Mangrove Ecosystem)	Raman spectroscopy	Soft tissue (after shell removal)	Grazer	Periphyton, diatoms	Fibers were common; polyurethane (PU) was the dominant polymer found	AL-TARSHI et al. 2025
40	*Tylothais aculeata* (Deshayes, 1844)	*Thalessa aculeata*	Balekambang Beach, southern Java, Indonesia (Marine Ecosystem)	ATR-FTIR spectroscopy	Soft tissue (after shell removal)	Herbivore	Algae, fungal & mangrove biofilm	Fragments are the dominant type of MPs	AMANDA et al. 2025
41	*Babylonia areolata* (Link, 1807)	Maculated Ivory Whelk or Spotted Babylon Snail	Chonburi Province, Thailand (Marine Ecosystem)	μ-FTIR spectroscopy	Soft tissue (after shell removal)	Scavenger/ Carnivore	Dead animals, worms, molluscs	Fibers, films, and fragments were present	WONGSOONTHORNCHAI et al. 2025
			Gulf of Thailand and Andaman Sea (Marine Ecosystem)	FTIR spectroscopy	Soft tissue (after shell removal)	Carnivore	Bivalves and other molluscs	Fibers are abundant, primarily composed of polyethylene terephthalate and polyester	SAETAN et al. 2026

cords (14), reporting MP contamination in 17 gastropod species, followed by the mangrove ecosystem with 12 studies and 12 species. Contamination in the marine ecosystem has been recorded in 17 species from 11 studies, and fewer species were studied in brackish water, with two species.

The reports studied showed that recent studies have focused on the inland and mangrove ecosystems as the major emerging MP storage sites (Akindele et al. 2019, Putri & Patria 2021, Zhao et al. 2024, Nikhil et al. 2024, Moin et al. 2025). The presence of MPs in gastropod molluscs varies across different ecosystems; extremely high concentrations of MPs were reported in the species *Telescopium telescopium* (368.51 particles / individual) and a complete absence of MPs in species *Laevistrombus canarium* (Putri & Patria 2021, Wongsoonthornchai et al. 2025). This variation may be influenced by species-specific feeding strategies, habitat conditions, differences in exposure to microplastics, selective feeding, possible gut clearance, and methodological differences in sampling and MP detection (Table 1).

ECOSYSTEM-WISE MPS DISTRIBUTION IN GASTROPODS

Freshwater ecosystems were the most studied ecosystems (14 studies) (Fig. 2) for MP contamination in gastropods, with 17 species documented from Africa, Asia, and Europe (Akindele et al. 2019, Xu et al. 2020, Jitkaew et al. 2023, Labcom et al. 2024, Gabetti et al. 2025). Fibres and films were the dominant MPs found in the Nigerian freshwater gastropod species *Lanistes varicus,* while two other species, *Melanoides tuberculata* and *Theodoxus fluviatilis,* showed exclusive accumulation of fibrous MPs composed of nylon and polypropylene (Akindele et al. 2019). Three gastropods, *Pomacea canaliculata, Filopaludina javanica,* and *Sulcospira* sp. of Indonesian river systems, have shown a severe level of MP contamination with textile fibres, cosmetic microbeads, and packaging films, and this is mainly due to anthropogenic activities (Buwono et al. 2025, Islamy et al. 2025). 90–100% of individuals of *Sinotaia aeruginosa* studied from Taihu lake, China, contain polymers such as PVA, PET, PS, and PA (Xu et al. 2020). Although MP contamination in gastropods of freshwater Europe was limited, the presence of MP was recorded in *Potamopyrgus antipodarum* and *Sinotaia quadrata,* with fragments and filaments composed mainly of polypropylene, polyethylene, and PET (Gabetti et al. 2025, Zilifli et al. 2025) (Table 1).

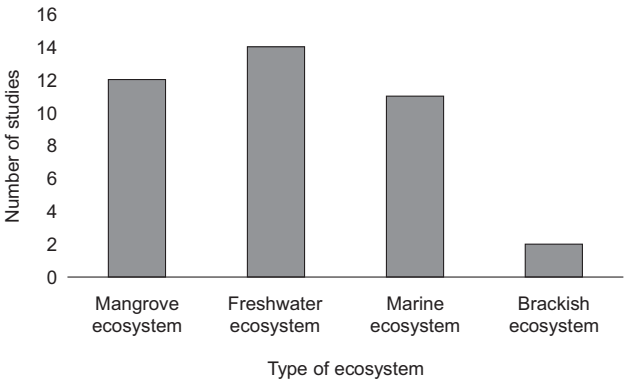

Fig. 2. Details of studies on MP contaminations in gastropod molluscs

MP contamination in gastropods from mangrove ecosystems was reported in 12 different studies (Fig. 2), and it showed the highest MP abundance per individual. The Telescope Snail, *Telescopium telescopium,* is one of the most studied mangrove gastropods, and multiple studies reported high MP accumulation and dominance (Table 1). However, the type of abundant MP contaminant differed among locations, with films in one location and fibres in another (Putri & Patria 2021, Yona et al. 2023). A trend was observed in both MP contamination level and MP abundance, with larger gastropod species exhibiting higher MP loads than smaller species (Putri & Patria 2021, Dar et al. 2023, Yona et al. 2023). Studies have shown that mangrove ecosystems are effective sinks of plastic debris, and particles accumulate in gastropods found in those ecosystems (Fitri & Patria 2019, Putri & Patria 2021, Moin et al. 2025). Baseline evidence for MP accumulation in a gastropod, *Cerithidea obtusa,* from mangrove ecosystems of Jambi, Indonesia, showed the presence of fibres, films, and fragments (Fitri & Patria 2019). MP abundance in another gastropod, *Littoraria scabra,* from Indonesian mangrove ecosystems showed a high dominance of fibres (66.89%) and a positive correlation between MP abundance and body weight (Patria et al. 2020). The gastropod *Babylonia spirata* from the Indus Delta, Pakistan, recorded the second most MP-abundant mangrove species with 30.87 ± 11.47 items per individual (Table 1). It exhibits a high concentration of microplastics, with fibres dominating, followed by fragments and films, highlighting severe pollution in the mangrove ecosystem (Moin et al. 2025). Indian mangroves show a predominance of transparent and fragment types of microplastics and polymers such as polyethylene, polypropylene, and polyurethane, which reveal the effect of urban plastic deposition (Dar et al. 2023).

In marine ecosystems, MP in gastropod species were reported from 11 studies showing contamination in 17 species (Fig. 2). Marine and semi-enclosed marine ecosystems also showed fibre dominance fol-

lowed by fragments and films due to shipping, fishing, offshore plastic deposition, etc. (Nikhil et al. 2024, Zhao et al. 2024). The Bohai Sea in China was the most intensively studied marine ecosystem, and multiple gastropods are also studied from this sea, including *Buccinum koreanum*, *Neverita didyma*, *Neptunea subdilatata*, and *Rapana venosa* (Table 1). They showed MP contamination dominated by fibres, fragments, and films, with polymers such as PE, PP, PS, PET, and PA (Zhao et al. 2024). Coastal gastropod *Dolomena turturella* from Singapore waters showed high MP abundance (273 particles per individual), with fibres and fragments as the dominant type, and major polymers are acrylic, polyamide, and PET (Curren et al. 2024). Estuarine and brackish water ecosystems also exhibit MP abundance invariably, with fibre as the dominant type, and larger gastropods may contain more MPs in absolute numbers, which does not necessarily indicate a higher MP burden per unit body weight (Barrows et al. 2018, Lindeque et al. 2020, Schuab et al. 2023, Abisha et al. 2024).

CHARACTERISTICS OF MICROPLASTICS IN GASTROPODS

Across all environmental ecosystems and species, fibres were the dominant type of MP, with about 60-90% of MPs being fibres in most studies (Patria et al. 2020, Zaki et al. 2021, Jitkaew et al. 2023). The second rank in abundance goes to fragments, particularly in marine and tropical ecosystems. In mangrove and freshwater ecosystems, films are the most frequently associated type of MPs (Akindele et al. 2019, Putri & Patria 2021, Nikhil et al. 2024). Due to cosmetic and industrial sources, microbeads and pellets are also rarely detected in some freshwater and mangrove ecosystems (Supriatna et al. 2023, Islamy et al. 2025) (Table 1).

Small-sized MPs were dominant in all types of ecosystems. More than 60–90% of MPs detected from gastropod tissues are <500 µm sized particles. This results in the ingestion of MP particles by gastropods (Putri & Patria 2021, Zhao et al. 2024). 100-300 µm sized particles were found in some mangrove-associated gastropods such as *Telescopium telescopium* and *Babylonia spirata* (Putri & Patria 2021, Moin et al. 2025). Particles larger than 1 mm were rarely detected (Xu et al. 2020, Jitkaew et al. 2023). The abundance of small-sized particles results in environmental persistence and a high rate of ingestion (Table 1).

When considering polymer-wise abundance, there is a clear dominance of low-density synthetic polymers. 30–60% of the total identified MPs were polyethylene (PE), which was the most abundant polymer type of microplastics found in freshwater, marine, and mangrove ecosystems due to its usage in plastic bags, packaging films, and household materials (Putri & Patria 2021, Zhao et al. 2024). Polypropylene (PP) was the second most abundant polymer found across marine and coastal gastropods, about 15–30% of total identified MPs; nylon, polyester, polyurethane, and acrylic fibres are also found in marine and coastal gastropods due to usage in ropes, fishing gear, and food containers (Do et al. 2022, Curren et al. 2024, Al-Tarshi et al. 2025). Polystyrene ranges between 5–20%, and common sources are fragmented foam and disposable products frequently counted in freshwater gastropods (Xu et al. 2020, Jitkaew et al. 2023). Polyethylene terephthalate (PET) and polyvinyl chloride (PVC) were rarely detected due to their higher density (Moin et al. 2025). Semi-synthetic cellulose fibres were also detected in one species (Ojeda et al. 2021) (Table 1).

Black is the dominant colour of MPs found in gastropods, followed by transparent, blue, red, and white (Zaki et al. 2021, Supriatna et al. 2023, Yücel & Kiliç 2023, Amanda et al. 2025, Moin et al. 2025, Rahman et al. 2025, Saetan et al. 2026). Among these, black fibres are common in marine and freshwater ecosystems (Zaki et al. 2021, Rahman et al. 2025). This may be due to detection bias, i.e., black particles are more easily visually identified than transparent or white ones.

BIOACCUMULATION AND TROPHIC TRANSFER

Due to the small size of microplastics that can be easily ingested by a wide range of marine organisms, from small-sized plankton to larger fish (Yona et al. 2023). Once consumed, these particles enter the food web, where they can accumulate in higher predators through biomagnification, posing potential ecological and health risks (Au et al. 2017). The size of the organism plays a significant role in MP contamination. Some gastropod species show a positive correlation between MPs accumulation and their body size, shell size, shell weight, and tissue weight (Jitkaew et al. 2023). The widespread presence of MP particles in environmental ecosystems leads to human exposure to various sources of MPs being unavoidable. These particles can enter the human body through biomagnification, inhalation, and

dermal contact (Abbasi & Turner 2021). By 2060, MPs will be 13.2% of the total weight of global plastic accumulation (Yadav et al. 2025). A study in the Sundarbans revealed that MP concentration in quaternary consumers had the highest levels, while primary consumers had the lowest (Sarker et al. 2022).

Organisms included in lower trophic levels are able to ingest MPs with food particles (Wright et al. 2013, Thushari & Senevirathna 2020). Trophic transfer of microplastics through both aquatic and terrestrial food chains has been demonstrated (Caputo et al. 2021). Accumulation of plastic debris causes not only negative ecological consequences to the ecosystem but also threatens the socio-economic aspects of human life in various ways (Thushari & Senevirathna 2020). Gastropods are consumed as seafood by humans, so it will likely be transferred from gastropods to humans (Curren et al. 2024). Analysis of MPs in human faeces showed a positive correlation between faecal MPs and inflammatory bowel disease (Yan et al. 2021). A study on the biomagnification of MPs concluded that lower taxa play a crucial role in human exposure to MPs due to their feeding habits (Walkinshaw et al. 2020).

Based on the studies summarised in Table 1, feeding habits appear to influence MP contamination in gastropods, although habitat and environmental pollution also play important roles. Because they consume sediment, biofilms, detritus, etc., which easily accumulate MPs, detritivores and grazers, including *Cerithidea obtusa, Telescopium telescopium, Melanoides tuberculata*, and *Patella caerulea,* often displayed greater MP burdens. Fibres and fragments were also frequently found in herbivorous species that consume algae and biofilms. *Rapana venosa, Babylonia areolata*, and *Buccinum koreanum* are examples of carnivorous and scavenging gastropods that most likely pick up MPs by trophic transfer from contaminated prey.

ECOTOXICOLOGICAL EFFECTS OF MICROPLASTICS – IN GENERAL

The effects of MPs on specific specimens are mostly investigated in marine species. However, some already report the effects on freshwater organisms. MPs can enter the circulatory systems of organisms through the intestinal tract (Tang et al. 2020). It was reported that particle sizes of 3.0 or 9.6 µm were found in the haemolymph of the blue mussel *Mytilus edulis* (Peng et al. 2020). However, particle sizes over 20 µm will be excreted by mussels without entering the haemolymph (Van Cauwenberghe et al. 2013). Aquatic organisms such as zooplankton, benthic invertebrates, bivalves, fish, and large marine mammals ingest MPs as food (Van Cauwenberghe et al. 2013, Su et al. 2016). Ingestion of MPs by marine animals blocks and damage the digestive organs, resulting in false satiety (Peng et al. 2020, Vo & Pham 2021). The extent of ecological disturbance depends on how the ecotoxicity of MPs is transported and proliferated throughout an aquatic environment.

Microplastics have direct biological effects by disturbing behavioural responses in gastropods, increasing their vulnerability to predation. This is crucial as the effects of anthropogenic stressors on species interactions could cascade up and down food webs (Seuront 2018). Few reports were available to assess the MPs' toxic effects in benthic organisms, but ingestion of MPs has adverse effects on their development, reduces the feeding rate, reproduction, alters behaviour, and causes physiological changes (Li et al. 2016, Sussarellu et al. 2016, Jeyavani et al. 2022, Kumari et al. 2023).

In other freshwater organisms, ingestion and accumulation of polypropylene MPs in actinopterygian fish, *Danio rerio* and the nematode worm, *Caenorhabditis elegans* caused oxidative stress, intestinal damage, and reduced the survival rate (Lei et al. 2018, Jeyavani et al. 2022). Acute and chronic exposure of polypropylene microplastics in the amphipod crustacean *Hyallela azteca,* affecting growth and reproduction (Au et al. 2017, Jeyavani et al. 2022). Exposure to MPs induces a spectrum of adverse physiological effects in marine organisms (e.g., bivalves *Perna viridis*, *Crassostrea gigas*), including oxidative stress, metabolic disturbances, immune system disruption, and tissue damage (Hou et al. 2024, Li et al. 2024, Xie et al. 2025).

RESEARCH GAP AND FUTURE DIRECTIONS

Several studies have been done on MP contamination in gastropods, but there are no records that gave consistent results or reports due to the lack of studies in some areas, like species-specific feeding strategy based on size, colour, and polymer, seasonal and spatial variations, habitat characteristics, etc. There is a need to develop more studies on physiological impacts, behavioural changes, reproduction strategies, and microbiome disruptions due to MP accumulation. Most studies are short-term and spatially limited, while long-term data are unavailable. Current studies are mainly focused on microplastics; nanoplastics (<1 µm) are another threat to face in the future, but there are no relevant studies on this.

CONCLUSION

These existing studies show that microplastic contamination in gastropods occurs in a wide range across freshwater, mangrove, marine, coastal, estuarine, brackish water, and semi-enclosed marine ecosystems. The mangrove ecosystem is the most affected ecosystem with MPs with a large number of particles per individual. Fibres and fragments are the dominant MPs in gastropods; small-sized MPs are mostly ingested by gastropods. Low-density polymers such as polyethylene and polypropylene are prevalent in gastropods. This condition has ecological implications and potential exposure risks for humans through the food chain. Therefore, strengthening monitoring, standardising methods, and reducing sources of coastal plastic pollution are important steps to reduce the risks of MPs on ecosystems and public health. Controlling plastic pollution, monitoring marine products, raising awareness of the public, and harmonising analytical methods are key to reducing ecological and health risks due to MPs.

AUTHOR'S CONTRIBUTION

AP, AK and RK prepared the draft of the manuscript. AP contributed to the collection and assembly of data, data analysis and interpretation, and writing of the article. AK critically revised the manuscript. RK contributed to the research concept and design, data analysis and interpretation, critical revision of the article, and final approval of the article. All authors read and approved the final manuscript.

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