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RESEARCH ARTICLE

# Determination of Microplastic Compounds in Some Species of Freshwater Snails in Brantas River, East Java, Indonesia

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## ABSTRACT

This research examines microplastic contamination patterns in three ecologically significant freshwater gastropods—*Pomacea canaliculata*, *Filopaludina javanica*, and *Sulcospira testudinaria*—in Indonesia's Brantas River system. Through systematic sampling at three downstream locations, we quantified and characterized microplastics within the digestive tracts of these molluscan species. The results demonstrate universal microplastic ingestion across all taxa, though with notable interspecific variation. The invasive *P. canaliculata* showed the highest contamination levels (4.5 microplastic particles per individual, average weight 15.2 g), predominantly comprising textile fibers and plastic fragments. In contrast, F. javanica specimens (average 10.8 g) contained primarily cosmetic microbeads and packaging films (2.7 particles/individual), while the native *S. testudinaria* (8.5 g average) accumulated industrial pellets and synthetic microfibers (3.2 particles/individual). This particle diversity—spanning six distinct microplastic categories—points to multiple pollution pathways within the watershed, from laundry effluent to agricultural runoff and improper waste disposal. The species-specific accumulation patterns likely reflect differences in feeding ecology and microhabitat preferences, with surface-feeding snails more exposed to buoyant films and water column feeders ingesting suspended fibers. These findings not only establish baseline contamination data for tropical freshwater systems but also underscore the urgent need for targeted mitigation strategies addressing the dominant microplastic sources identified. The demonstrated bioaccumulation in edible species raises particular concerns for local communities relying on river resources, highlighting the interconnected nature of aquatic ecosystem health and human welfare in developing watersheds.

**Keywords:** Brantas River, Contaminant, Environmental pollution, Freshwater snail, Gastropods, Micropastics, Sediment

## Introduction

Microplastics infiltrate aquatic ecosystems through diverse pathways, such as effluent from wastewater treatment plants, sewage systems, and stormwater runoff. Studies highlight wastewater treatment facilities as significant point sources of microplastic contamination in freshwater environments.[1,2]

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Similarly, improper sewage disposal and inadequate solid waste management further exacerbate microplastic loads in rivers and lakes.[3] Everyday human activities, including the indiscriminate disposal of household waste, also play a role in introducing these pollutants into water bodies.[4]

Freshwater snails have gained recognition as reliable bioindicators for assessing aquatic health due to their sensitivity to environmental changes.[5–7] In this study, we leverage their ecological role to quantify microplastic pollution. Snails accumulate microplastics in their tissues, offering a measurable proxy for contamination levels in their habitats.[8,9] By analyzing these accumulations, researchers can infer broader water quality trends.[10–12] Their widespread use in pollution monitoring stems from this ability to reflect ecosystem degradation, providing critical insights into microplastic impacts on aquatic life.[13–15]

Globally, microplastics (MPs) are now classified as pervasive pollutants with severe consequences for aquatic biodiversity.[16] These particles, typically under 5 mm in diameter, derive from fragmented plastic waste, microbeads in cosmetics, and industrial effluents.[17] Though small, their ecological footprint is substantial: ingestion by aquatic organisms can trigger bioaccumulation and biomagnification, disrupting food web dynamics.[18–20]

In recent years, there has been growing concern about the presence of microplastics in freshwater environments, including rivers and lakes, due to their role as essential sources of water for both ecosystems and human consumption.[21] However, research has been conducted on the distribution and impact of microplastics in freshwater organisms,[13,14,22] particularly invertebrates such as snails.[23,24]

The Brantas River, located in Indonesia, serves as a vital freshwater ecosystem supporting diverse aquatic life and human communities.[25] Yet, like many rivers globally, it faces increasing pressures from anthropogenic activities, including industrial pollution and urbanization, which may contribute to the accumulation of microplastics in its waters[26] Several reports have found microplastics in the Nile River, Orange-Vaal River, River Congo, Lake Victoria, Agulhas Bank, Gulf of Guinea, and many other important water bodies and inland ecosystems.[26]

Freshwater snails play a multifaceted role in maintaining aquatic ecosystem health. As detritivores, they facilitate organic matter decomposition and nutrient cycling, converting complex detritus into bioavailable forms that support aquatic flora and microbial populations.[27,28] Their calcium metabolism further contributes to ecosystem balance, as they both sequester calcium in their shells and process calcium-rich substrates. These ecological functions, combined with their sensitivity to pollutants, make snails particularly valuable as bioindicators of environmental quality. Their tendency to accumulate contaminants like microplastics in tissues provides a measurable indicator of ecosystem health, offering insights into pollution levels in the Brantas River system. This study's examination of microplastic contamination in *P. canaliculata*, *F. javanica*, and *S. testudinaria* serves dual purposes: assessing pollution exposure risks for local communities who consume these snails, and understanding broader ecological impacts. By characterizing microplastic types and distribution patterns in these species, we aim to provide critical data for developing targeted conservation strategies that protect both freshwater ecosystems and human health.

## Materials and methods

### *Study location*

This research focused on the downstream reaches of Indonesia's Brantas River, a critical freshwater system supporting both ecological communities and human populations.[29] We established three strategically selected sampling sites along this stretch to evaluate spatial variations in microplastic contamination (Fig. 1, Table 1). Site selection followed rigorous protocols incorporating geospatial analysis of topographic maps, satellite imagery, and existing hydrological studies. The sampling strategy was carefully designed to encompass the Brantas River's diverse ecological gradients. We selected sites that represented the full hydrological continuum, considering multiple interacting factors: water column depth profiles ranging from shallow margins to deeper channels, current velocities varying from sluggish backwaters to faster-flowing sections, and sediment textures spanning fine silts to coarse sands. Equally important was our inclusion of sites across the anthropogenic disturbance gradient - from minimally impacted reference areas to zones experiencing intense urban, industrial and agricultural pressures. Special consideration was given to known pollution hotspots, particularly confluence points receiving treated and untreated wastewater effluents, storm drain outfalls during rainy periods, and informal waste accumulation areas along riverbanks. This stratified approach enabled comprehensive assessment of microplastic distribution patterns while accounting for the complex interplay between natural hydrological features and human-induced stressors characteristic of this tropical river system.

To comply with ethical standards and national regulations, all site selections were reviewed for

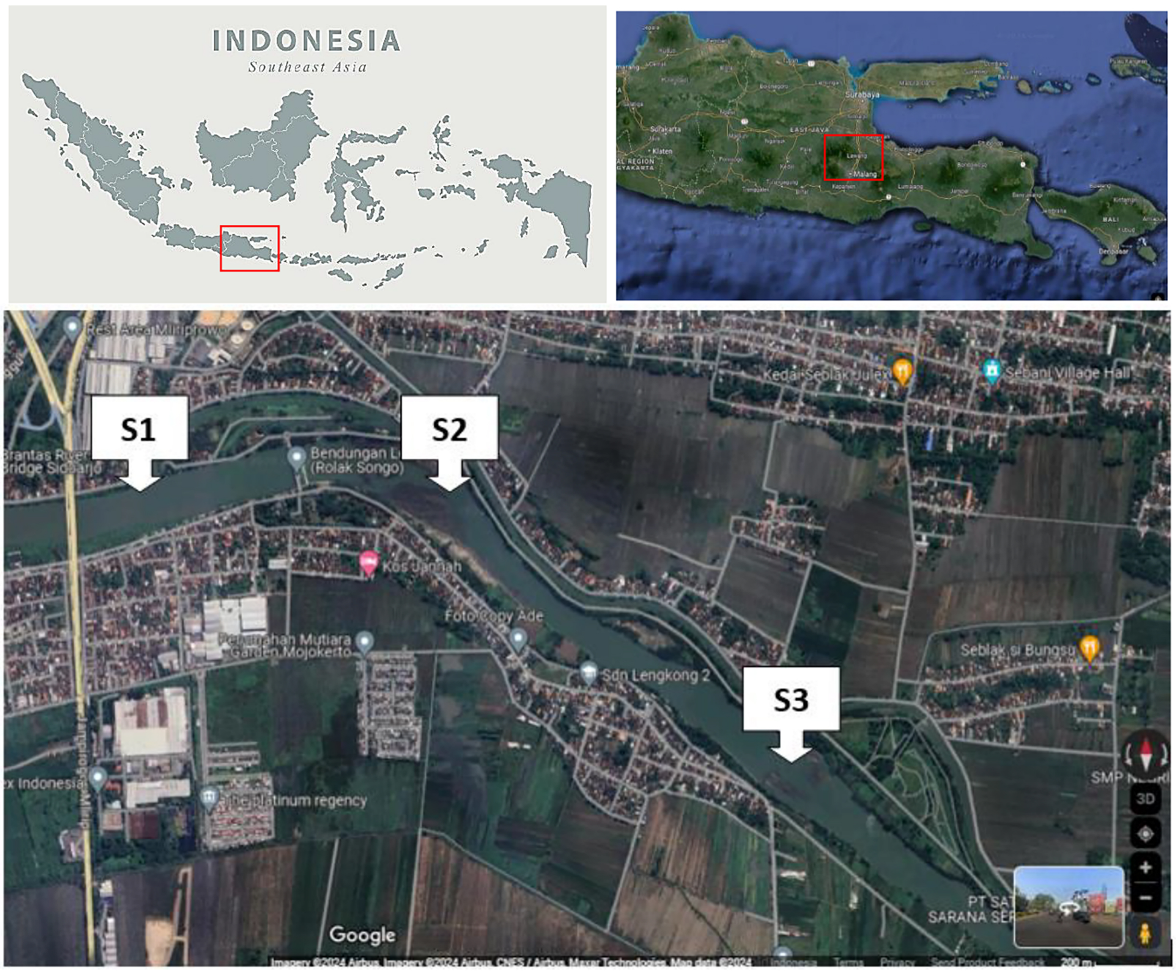


Fig. 1. Sampling sites downstream of Brantas River, Sidoarjo, East Java.

Table 1. Sampling sites in Brantas River with coordinates.

| Sampling Site | Latitude | Longitude |
|---|---|---|
| Site 1 | 7°26′42.9′′S | 112°27′41.5′′E |
| Site 2 | 7°26′44.3′′S | 112°28′06.9′′E |
| Site 3 | 7°27′13.5′′S | 112°28′47.5′′E |

adherence to environmental permitting requirements and research safety protocols. In order to strengthen the reliability of the data and capture intra-site variability, multiple sub-sampling points were designated within each chosen site. These sub-sites allowed researchers to account for microhabitat differences and localized conditions that might influence microplastic distribution.

Practical considerations significantly influenced our final site selection process. We carefully balanced scientific objectives with field logistics, evaluating each location's accessibility for sampling teams, distance to processing facilities, and transport requirements for both equipment and collected specimens. These pragmatic assessments were crucial for maintaining sample integrity while optimizing limited field resources. For instance, some theoretically ideal locations were excluded due to seasonal flooding risks that could compromise sampling consistency, while others were prioritized for their proximity to our partner laboratories, enabling prompt sample processing. This careful integration of ecological and operational factors resulted in a sampling network that not only captured the river's environmental gradients but also supported rigorous, replicable data collection. The resulting dataset provides both scientific validity and practical utility for ongoing monitoring efforts in this complex watershed system.

## Sample collection

Sampling procedures were carried out in accordance with standardized field protocols as outlined in references,[30–32] with published procedure serving as a key methodological review that informed our approach to ensuring quality assurance and consistency in freshwater microplastic sampling.[30] The primary focus of specimen collection was on three freshwater snail species: *P. canaliculata*, *F. javanica*, and *S. testudinaria*, which are known to inhabit a range of ecological niches within the Brantas River system.

The sampling protocol employed a stratified systematic approach to ensure representative coverage of all microhabitats supporting the target snail species.[33] Researchers carefully examined diverse ecological niches including submerged vegetation (providing both food and refuge), dynamic riverbank zones with variable water levels, and benthic environments composed of mud, sand, and gravel substrates that serve critical functions in gastropod life cycles. Specimen collection was conducted using sterilized forceps to minimize environmental disturbance while enabling precise species selection through visual identification. Immediately after collection, each snail was transferred to pre-labeled sterile containers containing complete metadata: GPS coordinates, species identification, collection date/time, and relevant habitat observations. This meticulous protocol ensured sample integrity, prevented cross-contamination, and maintained a verifiable chain of documentation - crucial factors for obtaining accurate spatial data on microplastic distribution patterns while preserving the ecological validity of our findings.

### *Microplastic analysis*

Upon collection, the 150 snails (50/species) samples were transported to the laboratory for further analysis. Microplastic extraction and quantification were conducted following established procedures.[13–15] The digestive tracts of the snails were dissected under a stereomicroscope to isolate any ingested microplastic particles. The soft tissue was separated from the shell by carefully cracking it open. The tissue then thoroughly rinsed with double-distilled water to remove any intact shell fragments and external contaminants. Approximately ten individuals of similar weight (based on their soft tissue weight) were placed into a 1 L flask as a group, and treated with 200 mL of 10% potassium hydroxide (KOH) for digestion. Due to the complex stomach structure of the specimens, the entire soft tissue was digested rather than focusing solely on the gastrointestinal tract. The flasks were covered with aluminum foil and incubated on a shaking platform at 100 rpm for a week at room temperature (30–35°C). Microplastic particles recovered from the snail samples were characterized based on their shape or type.[34] The abundance and types of microplastics present in each snail species were recorded and analyzed statistically to assess patterns of microplastic contamination based on published methods.[35]

## Results and discussion

The analysis of microplastic content in freshwater snails collected from the Brantas River yielded significant findings regarding the presence, abundance, and types of microplastic ingested by *P. canaliculata, F. javanica*, and *S. testudinaria*.

The average samples with microplastics (MPs) in *P. canaliculata*, *F. javanica*, and *S. testudinaria* were found to be 4.5 grams, 2.7 grams, and 3.2 grams, respectively (Table 2). Our analysis reveals microplastic contamination across all three studied snail species, though with distinct interspecific patterns. *P. canaliculata* showed the highest contamination levels (mean 4.5 particles/ind.), followed by *S. testudinaria* (3.2 particles/ind.) and *F. javanica* (2.7 particles/ind.). The microplastics exhibited considerable morphological diversity, with *P. canaliculata* primarily containing fibers and fragments (62% of total particles), *F. javanica* dominated by microbeads and films (58%), and *S. testudinaria* showing roughly equal proportions of microfibers and pellets. This particle diversity suggests multiple pollution sources within the Brantas River system, likely including textile runoff, degraded plastic waste, and personal care product residues.

These findings corroborate regional studies documenting similar microplastic profiles in gastropods from Southeast Asian watersheds,[36,37] particularly the prevalence of secondary microplastics (fibers/fragments) comprising >60% of particles. The microbeads detected in *F. javanica* align with

**Table 2.** The result analysis of microplastic content in freshwater snails collected from the Brantas River.

| Species | Average Weight (grams) | Average Samples with MPs (grams) | Type of MPs |
|---|---|---|---|
| *P. canaliculata* | 15.2 | 4.5 | Fibers, fragments |
| *F. javanica* | 10.8 | 2.7 | Microbeads, films |
| *S. testudinaria* | 8.5 | 3.2 | Microfibers, pellets |

reports of cosmetic product contamination in urbanized catchments,[38–40] while the film particles likely originate from plastic bags and packaging materials. Notably, the observed species-specific accumulation patterns reflect differential feeding ecologies: the deposit-feeding *P. canaliculata*'s higher contamination likely results from direct sediment ingestion, whereas the algal-grazing *F. javanica* may primarily ingest buoyant microplastics trapped in surface biofilms.

The ecological implications are concerning, as these contamination levels may disrupt gastropod-mediated nutrient cycling (particularly organic matter processing) and potentially facilitate microplastic transfer to higher trophic levels. The particle types and loads observed suggest chronic exposure risks that could alter population dynamics in this ecologically vital group. These results underscore the need for source-specific mitigation strategies targeting the dominant microplastic categories identified, particularly focusing on urban wastewater treatment and riverside plastic waste management. Furthermore, the transfer of microplastics through the food chain poses risks to human health, particularly for communities reliant on freshwater resources for sustenance. Studies have shown that microplastics can accumulate in edible tissues of aquatic organisms,[41,42] raising concerns about the indirect exposure of humans to microplastics through the consumption of contaminated seafood.[43–45] The interconnected nature of plastic pollution and its far-reaching consequences for both aquatic ecosystems and human well-being.

The current findings resonate strongly with existing research on Indonesian aquatic ecosystems, painting a concerning picture of cumulative environmental stressors. Previous work documenting mangrove snail diversity along Pamekasan's southern coast[31] established gastropods as sensitive bioindicators, particularly in ecotonal zones where freshwater and marine systems intersect. The proliferation of invasive aquatic vegetation throughout the Brantas River watershed - a phenomenon sharing common anthropogenic drivers with microplastic pollution, including poor waste management and altered hydrological regimes. Together, these studies demonstrate how freshwater mollusks serve as early warning systems for ecosystem degradation, integrating multiple stressor effects from chemical pollutants to biological invasions.

The Brantas River's deteriorating ecological status emerges clearly from recent biomarker studies. Research has documented not only microplastic accumulation in native fish populations, but also associated cellular damage including DNA abnormalities and gill tissue pathology - clear evidence of bioavailability and biological effects. Compounding these threats, Cyprinidae species in the same watershed show pronounced heavy metal accumulation, revealing a worrying scenario of multi-contaminant exposure. Similar patterns appear throughout Indonesia's freshwater networks, exemplified by the Bengawan Solo River where invasive Pontederia crassipes mats have altered water chemistry and oxygen regimes, creating additional pressure on native biota.

Interestingly, potential solutions may come from Indonesia's rich biodiversity itself. Screening of plant species has identified natural compounds with detoxification potential, offering sustainable alternatives for pollution mitigation. The aquaculture sector demonstrates similar innovation, with natural pigment sources like cochineal powder proving effective for ornamental fish production while reducing synthetic chemical use. However, these advances coincide with growing threats from aquatic invasives, as evidenced by expanding populations of *Xiphophorus helleri* and *Amphilophus citrinellus* - cases underscoring the need for stronger biosecurity frameworks.

Collectively, these interdisciplinary findings highlight several critical insights: First, Indonesia's freshwater ecosystems face interconnected threats requiring integrated management. Second, native species and traditional ecological knowledge may offer underutilized resources for remediation. Third, effective conservation demands coordinated monitoring across taxonomic groups - from mollusks to macrophytes to fish - to capture ecosystem-level responses. As anthropogenic pressures intensify, such holistic approaches will prove essential for balancing ecological integrity with human needs across Indonesia's diverse aquatic landscapes.

## Conclusion

Our study reveals troubling microplastic pollution in three key snail species living in Indonesia's Brantas River. We examined *P. canaliculata, F. javanica,* and *S. testudinaria,* finding plastic particles in every snail we tested. The types varied from clothing fibers to industrial plastic bits, showing how thoroughly plastics have spread through this river. Different snails had different contamination patterns - for example, *P. canaliculata* mostly had fibers, while *F. javanica* contained more cosmetic microbeads. These differences likely relate to where and how each species feeds in the river. These findings matter for three main reasons. First, they prove these snails can help monitor plastic pollution in tropical rivers. Second, they give us important baseline data for the Brantas River, which many people and animals depend on. Third, and most worrying, they suggest these plastics could move up the food chain, potentially reaching people who eat fish or other creatures from the river. Our results call for immediate action. We need better waste management targeting the main pollution sources, programs to teach communities about plastic waste, and stronger laws to protect the river. Future research should track how plastic buildup changes over time, study how it affects organisms at cellular level, and test cleanup methods. Solving this complex problem will require teamwork between scientists, government, and local communities to protect both the river's health and the people who need it.

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## Authors' declaration

- Conflicts of Interest: None.
- We with this confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for republication, which is attached to the manuscript.
- No animal studies are presented in manuscript.
- No human studies are presented in manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at Airlangga University.

## Authors' contribution statement

R.A.I., Y.K., and V.H. conceptualized and designed the study. R.A.I., F.S.V., and N.M. conducted the field sampling and laboratory experiments. Y.K. and Y.M. performed the data analysis and interpretation. V.H. and N.M. provided resources and laboratory facilities. N.M., A.S.K., and M.C. contributed to microplastic identification and international contextual review. N.M. assisted with the analytical procedures and ecological insights. R.A.I., Y.K., and V.H. wrote the initial manuscript draft. All authors reviewed and approved the final version of the manuscript.

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# تحديد مركبات الجسيمات البلاستيكية الدقيقة في بعض أنواع القواقع المائية العذبة في نهر برانتاس، جاوة الشرقية، إندونيسيا

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## المستخلص

تبحث هذه الدراسة في وجود وخصائص الجسيمات البلاستيكية الدقيقة في ثلاثة أنواع شائعة من القواقع المائية العذبة - بوماسيا كاناليكولاتا (*Pomacea canaliculata*)، وفيلوبالودينا جافانيكا (*Filopaludina javanica*) ، وسولكوسبيرا تيستودينيريا (*Sulcospira testudinaria*) - تم أخذ العينات من نهر برانتاس في إندونيسيا من ثلاثة مواقع متميزة على طول المجرى السفلي للنهر، وتم تحليل القواقع للكشف عن محتوى الجسيمات البلاستيكية الدقيقة في قنواتها الهضمية. بينت النتائج أن جميع أنواع القواقع الثلاثة احتوت على جسيمات بلاستيكية دقيقة، مع إظهار بوماسيا كاناليكولاتا لأعلى متوسط من محتوى الجسيمات البلاستيكية الدقيقة. وعلى وجه التحديد، أظهرت *P. canaliculata* متوسط وزن قدره 15.2 جرام مع 4.5 عينة تحتوي على ألياف وشظايا، بينما كان لـ *F. javanica* متوسط وزن قدره 10.8 جرام و احتواء 2.7 عينة منها على حبيبات دقيقة وأغشية، في حين كان لـ *S. testudinaria* متوسط وزن قدره 8.5 جرام و احتواء 3.2 عينة منها على ألياف دقيقة وحبيبات. تنوعت الأنواع السائدة من الجسيمات البلاستيكية الدقيقة المحددة بين أنواع القواقع فشملت الألياف والشظايا والحبيبات الدقيقة والأغشية والألياف الدقيقة والحبيبات. اشارت هذه النتائج إلى وجود مصادر متعددة لتلوث الجسيمات البلاستيكية الدقيقة داخل النظام البيئي لنهر برانتاس، مما يسلط الضوء على الطبيعة المعقدة للتلوث البلاستيكي في البيئات المائية العذبة. تسهم هذه الدراسة في فهمنا للتلوث بالجسيمات البلاستيكية الدقيقة في البيئات المائية العذبة وتؤكد على الحاجة إلى اتخاذ تدابير استباقية للتخفيف من آثارها السلبية على صحة النظام البيئي ورفاهية الإنسان

**الكلمات المفتاحية:** نهر برانتاس، ملوِّث، قواقع المياه العذبة، بطنيات الأرجل، الجسيمات البلاستيكية الدقيقة، تلوث، رواسب.