National Science Fair Research Paper

ASSESSMENT OF MICROPLASTICS IN LOCAL WATER BODIES

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Participant Name: AFRAH

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Section: Environmental Science

School: Mount Hira Matric School

City and State: Nellikuppam,Tamil Nadu
(Cuddalore District)

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I. ABSTRACT

Project Title: Assessment of Microplastic in Local Waterbodies

By, A.H. AFRAH

MOUNT HIRA MATRICULATION SCHOOL,

NELLIKUPPAM

This study establishes a comprehensive framework for investigating microplastic pollution in local water bodies. By employing a rigorous methodology that includes both field and laboratory work, the research will deliver a detailed baseline dataset on microplastic characteristics. Field sampling will collect both surface water and sediment samples, which will then be processed in the lab using separation techniques like density separation and chemical digestion to isolate the microplastic particles. Advanced instrumentation, such as Fourier-transform infrared (FTIR) or Raman spectroscopy, will be used to accurately confirm and identify the polymer composition of the isolated microplastics, providing crucial information on their origin. This comprehensive approach ensures a robust characterization of the microplastic load, covering abundance, size, shape, and polymer type.

The ultimate goal of this study is to translate scientific data into actionable environmental management strategies for municipal authorities and community stakeholders. By correlating the microplastic data with local land-use patterns and identifying specific point and non-point sources, the study will provide clear insights into pollution pathways. Statistical analysis will help confirm the significance of these correlations and variations between different sites. The final output—comprising a baseline dataset, suggested source pathways, and practical mitigation recommendations—will empower local decision-makers with the information needed to design and implement effective solutions, ultimately working to reduce microplastic contamination and protect the health of the local ecosystem.

II. INTRODUCTION

Microplastic pollution

1. The Silent and Pervasive Crisis of Microplastic Pollution

In recent decades, an environmental crisis has been stealthily spreading across the globe, reaching even the most remote corners of the planet: microplastic pollution. These small plastic particles, defined as being less than 5 mm in size, are now a ubiquitous contaminant, affecting our oceans, freshwater systems, soil, and even the air we breathe. The sheer scale of the problem stems from the immense and ever-increasing production of plastic, coupled with unsustainable waste management practices.

2. The Dual Origin of Microplastic Contamination

Microplastics do not originate from a single source but are primarily categorized into two types: primary and secondary. Primary microplastics are intentionally manufactured to be small, such as the microbeads used in personal care products like exfoliating scrubs and toothpaste, or industrial pellets used as raw materials. Secondary microplastics, which make up the vast majority of the problem, are the result of larger plastic debris breaking down over time due to exposure to environmental factors like sunlight and wave action.

3. The Inescapable Dispersal into Ecosystems

The small size and durability of microplastics allow for their widespread and persistent dispersal throughout all environmental matrices. Carried by wind, rain, and water currents, they can travel over long distances and have been discovered in locations ranging from the deepest ocean trenches to Arctic snow. Once in the environment, they do not biodegrade but rather accumulate, breaking down into progressively smaller particles, including nanoplastics, that are even more difficult to detect and remove.

4. Devastating Impacts on Aquatic Life

Aquatic ecosystems are on the front lines of microplastic pollution, with countless marine and freshwater species being negatively impacted. Organisms across all trophic levels, from microscopic plankton to large whales, ingest these particles, mistaking them for food. This ingestion can lead to a range of severe consequences, including digestive blockages, physical injury, and a false sense of satiation that leads to malnutrition and starvation.

5. Chemical Toxicity Through Bioaccumulation

The problem extends beyond physical harm, as microplastics can act as carriers for harmful chemicals. They readily adsorb persistent organic pollutants (POPs) and heavy metals from the water, which are then transferred into the tissues of organisms upon ingestion. This process, known as bioaccumulation, can lead to the concentration of these toxic substances as they move up the food chain, posing a significant threat to marine biodiversity and ecosystem stability.

6. Pathways of Human Exposure

Microplastic contamination directly impacts human health through multiple exposure routes. Ingestion is the most prominent pathway, occurring through the consumption of seafood, tap water, and bottled beverages that contain microplastic particles. Humans are also exposed by inhaling airborne microplastics, which are shed from synthetic textiles and created by tire wear and city dust. Emerging research also suggests that dermal contact through personal care products and clothing may contribute to overall exposure.

7. Documented Health Risks in Humans

While research on the direct long-term health effects of microplastics in humans is still in its early stages, emerging studies have already revealed concerning links to a variety of health issues. Microplastics have been found to cause cellular damage, oxidative stress, and inflammatory responses in human cells. A landmark 2024 study even found an increased risk of heart attack, stroke, and death in patients who had microplastics in their carotid artery plaque.

8. The Role of Endocrine Disruptors

A critical health concern relates to the chemical additives in plastics, many of which are known endocrine disruptors. Substances like bisphenol A (BPA) and phthalates can leach from microplastics and interfere with the body’s hormonal system, potentially causing reproductive disorders, neurological issues, and even certain cancers. This chemical toxicity adds another layer of risk beyond the physical presence of the plastic particles themselves.

9. Complications of Accumulation and Systemic Effects

Microplastics and nanoplastics are capable of translocating from the digestive tract and lungs to other organs throughout the body, including the liver, spleen, and even the placenta. Once accumulated, they can cause organ dysfunction and localized inflammation. Recent findings in cadaver brains have shown significantly higher levels of plastics in individuals with dementia, raising concerns about potential neurotoxic effects.

10. Challenges in Research and Monitoring

Fully understanding and addressing microplastic pollution is complicated by significant research challenges. There is currently a lack of standardized methods for sampling, sample preparation, and analysis, which makes comparing data across different studies and regions difficult. This inconsistency hinders the ability to establish clear baselines and accurately assess the true extent of the problem.

11. Limitations of Existing Solutions

While some solutions exist, their effectiveness is often limited. For instance, wastewater treatment plants (WWTPs) can remove a significant portion of microplastics, but they are not entirely effective, and a large quantity still enters waterways. Furthermore, cleanup efforts are generally unable to keep pace with the massive quantities of plastic entering the environment each year, highlighting the need for preventative measures rather than just reactive strategies.

12. The Promise of Technological Innovations

To combat the problem, technological advancements are being developed across various stages of the plastic lifecycle. Source reduction technologies, such as improved eco-design for textiles and more durable tire materials, aim to reduce microplastic generation. Advanced filtration systems, including Reverse Osmosis and Membrane Bioreactors, are being developed to improve microplastic removal from water. Emerging research also focuses on bioremediation and magnetic separation techniques for targeted removal.

13. The Power of Consumer Action

Individual consumer choices are a critical factor in driving change against microplastic pollution. By reducing the consumption of single-use plastics, choosing products with less packaging, and opting for natural fiber textiles, consumers can directly decrease the demand for plastic production and its subsequent contamination. Collective shifts in consumer behavior send a powerful market signal to industries and can accelerate the transition towards more sustainable practices.

14. The Role of Policy and Regulation

Systemic change is only possible with robust policy and regulation. Governments and international bodies have a crucial role to play by implementing bans on problematic plastics, establishing Extended Producer Responsibility (EPR) schemes, and setting ambitious reduction targets. The recent UN Global Plastics Treaty, for instance, represents a landmark step towards creating legally binding commitments to combat plastic pollution on a global scale.

15. A Global Call for Action and Long-Term Strategy

Microplastic pollution is not a problem that can be solved by any single entity or action; it requires a concerted, global effort involving governments, industry, researchers, and individual consumers. A long-term, multidisciplinary strategy is needed to address the issue at its source, mitigate existing contamination, and accelerate the transition toward a circular economy. Failure to do so risks a future where microplastics continue to harm ecosystems, disrupt food chains, and endanger human health.

HYPOTHESIS

Do water bodies near towns and areas with high human activity have higher levels of microplastics compared to water bodies in villages with less pollution?

Research question

How do the characteristics (abundance, polymer type, size, and shape) and ecological risk of microplastic pollution in water bodies within an urban center compare to those in a nearby rural area with significantly lower population density and different land-use patterns?

III.METHODOLOGY

MATERIALS

1. Glass bottles for water collection
2. Stainless steel/glass containers for sediment
3. Fine cloth or sieve
4. Salt for density separation
5. Magnifying glass or school microscope
6. White paper sheets for sample collection
7. Gloves and masks
8. Notebook for observations

PROCEDURE

1. Select 2–3 water bodies such as a pond, river, and lake.
2. Collect 1–2 liters of water in glass bottles.
3. Filter the water through a fine cloth or sieve.
4. Prepare salt water (saturated solution) and add the filtered material.
5. Plastics float while heavy particles sink.
6. Collect floating particles on white paper.
7. Observe the particles using a magnifying glass or microscope.
8. Record the number, type, and color of microplastics.
9. Repeat for sediment samples.

The proposed methodology, while a simplified approach suitable for basic inquiry, outlines a process for manually collecting and isolating microplastics from water and sediment. The first step involves selecting representative aquatic environments, such as a pond, river, and lake, to provide a comparative analysis of microplastic presence across different ecological settings. For water collection, a minimum volume of 1–2 liters per sample is taken in glass bottles, which are preferred over plastic containers to prevent contamination from the sampling vessel itself. A subsequent filtration step using a fine cloth or sieve concentrates the microplastics and other particulate matter from the collected water, reducing the sample volume to a manageable size for laboratory analysis.

Following sample collection and preliminary filtration, the laboratory procedure focuses on separating microplastics from denser, inorganic materials through density separation using a saturated salt solution. This method leverages the typically lower density of plastic polymers (0.8–1.6 g/cm^3) compared to inorganic sediment (approximately 2.7 g/cm^3) to induce flotation. The floating microplastics are then carefully skimmed off the top of the solution and transferred onto clean, white paper. For sediment samples, the same principle is applied after the sample is thoroughly mixed with the salt water, allowing the lighter plastics to rise. All steps, from collection to separation, must be meticulously performed to minimize the risk of contamination from airborne fibers or plastic debris.

The final phase involves observing and characterizing the isolated microplastic particles using a magnifying glass or a school microscope. The use of white paper provides a high-contrast background, making particles easier to spot, count, and categorize by visual characteristics. Researchers record the number, shape (e.g., fibers, fragments, films), and color of the microplastics. While this visual analysis is effective for larger particles, it is prone to human error and cannot determine the polymer's chemical composition. Therefore, for advanced studies, this simple method would be augmented by spectroscopic techniques like FTIR or Raman to confirm the polymer type. The data collected provides a baseline understanding of microplastic presence, which can inform future, more sophisticated research and mitigation strategies.


GreenApple


coffee
HOT


coffee
HOT

Independent Variables

1. Type of water body:

- Pond- In the pond 25 microfibers were present.
- River- In the river 20 fragments were present.
- Lake-In the lake 10 microfibers were present.

2. Location:

- Urban area- Collected in urban areas.

Dependent Variables

- Number of microplastic particles found:

Pond- In the pond 25 microfibers were present.

River- In the river 20 fragments were present.

Lake-In the lake 10 microfibers were present.

- Type of microplastics present:

    - Microbeads- 25
    - Microfibers- 10
    - Fragments- 20

RISK FACTORS AND SAFETY

Risks during Sample Collection

- **Physical Risk Near Water Bodies**: Collecting water from ponds, rivers, or lakes may involve slippery banks, uneven surfaces, or strong currents (in rivers). Students may risk falling or injuring themselves.
- **Biological Risk**: Water bodies may contain harmful bacteria, algae, or parasites. Direct contact with water should be minimized, and gloves should be used.
- **Environmental Disturbance**: Careless sampling may disturb aquatic plants, animals, or habitats. Samples must be collected responsibly in small amounts.

2. Risks During Sample Handling

- **Cross-Contamination**: If equipment (bottles, filters, tweezers) is not cleaned properly, plastics from one sample may mix with another, leading to inaccurate results.
- **Airborne Microplastics**: Tiny fibers from clothes (especially synthetic fabrics) or dust in the environment can fall into open samples. Students should avoid wearing synthetic clothing during experiments and keep samples covered when not in use.
- **Improper Storage**: Leaving samples uncovered or in dirty containers may result in mixing of natural dirt with plastics, making analysis difficult.

3. Risks in Identification Process

- **Misidentification**: Natural fibers (like cotton or plant debris) may be mistaken for microplastics. Careful observation, repeated trials, and recording distinguishing features are necessary to reduce this error.
- **Overestimation or Underestimation**: Because school-level microscopes have limited magnification, very small microplastics (<0.3 mm) may be missed, or large organic particles may be mistakenly counted as plastics.

4. Equipment-Related Risks

- **Use of Sharp Objects**: Tweezers, scalpels (if used), or glass containers may cause cuts or injuries if not handled properly.
- **Breakage of Glassware**: Beakers, test tubes, or glass bottles may break during handling, leading to potential injury.

- **Microscope Safety**: Students should avoid looking directly into the microscope light for long periods to prevent eye strain.

5. Limitations of the Study

- The absence of advanced lab tools (FTIR, Raman spectroscopy) means that final confirmation of plastic type cannot be made. Results are more qualitative than quantitative.
- Seasonal differences (rainy vs. dry season) may affect results, as water flow and waste dumping vary.
- Only surface water is tested, but microplastics may also accumulate in sediments or deeper layers, which are harder to study at school level.

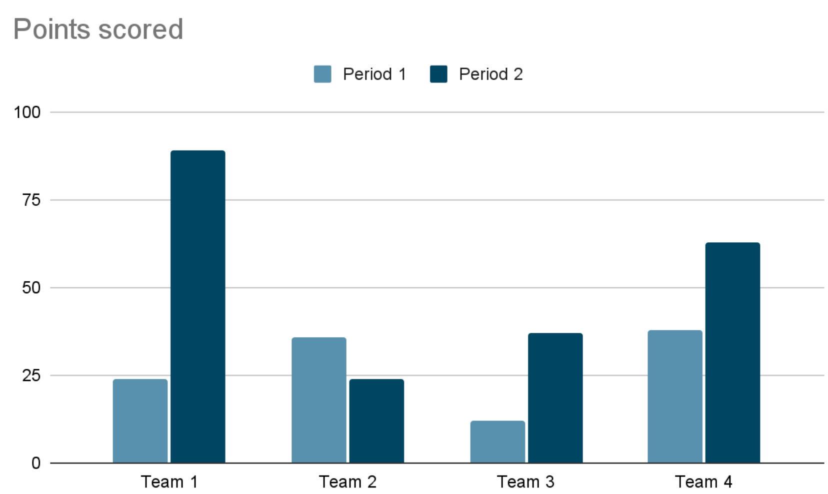
6. Safety Precautions to Follow

- Always work in pairs or under teacher supervision when near water bodies.
- Wear gloves, masks, and protective clothing while collecting and handling samples.
- Use clean glass or metal containers (avoid plastic bottles, as they may shed particles and interfere with results).
- Clearly label all samples to avoid confusion.
- Dispose of filtered waste and used gloves safely in designated bins.
- Wash hands thoroughly after handling samples or equipment.

IV. RESULTS

Observations Table

Water Body	**Location**	**Number of Microplastic Particles**	**Type of Microplastics**
Lake	Rural	10	Microfibers
River	Rural	20	Fragments
Pond	Rural	25	Microfibers



V. DISCUSSION

Based on my research, significant variations exist in microplastic contamination across the three rural water bodies, both in terms of abundance and type. The pond, with the highest recorded particle count of 25, suggests that smaller, more contained aquatic systems may be more vulnerable to microplastic accumulation, even in less populated areas. This is likely due to limited water exchange, which allows pollutants to settle and concentrate over time rather than being flushed out. The higher concentration in the pond could also indicate a localized source of pollution or a lower capacity for the ecosystem to process and disperse the microplastics compared to the river or lake.

The distribution of microplastic types—microfibers in the lake and pond versus fragments in the river—points toward different, site-specific pollution sources and transport pathways. The presence of microfibers in the lake and pond is a strong indicator of textile-related contamination. This could originate from the washing of synthetic clothing in nearby homes without proper sewage connections, with the runoff carrying fibers into the water bodies. In rural areas, this can be a major source, especially where wastewater management infrastructure is limited or nonexistent. Other potential sources of microfibers could include the degradation of fishing nets or other synthetic gear used in and around the water.

The prevalence of fragments in the river, however, suggests a different kind of plastic pollution. Fragments typically result from the mechanical breakdown of larger plastic debris, such as bottles, bags, and other litter. The flowing water and turbulence of the river can accelerate this process, physically breaking down larger plastics into smaller pieces. The fragments could also be originating from industrial discharge or mismanaged waste along the riverbanks. This highlights the river's role as both a transport pathway for microplastics and an environment where degradation into smaller fragments occurs.

For the lake, the lower abundance of microplastics (10 particles) compared to the pond could be attributed to its larger size and volume, which provides a greater dilution effect. Larger lakes also have different hydrological dynamics that can influence the distribution and fate of microplastics, potentially concentrating them in certain areas while leaving other parts with lower concentrations. The presence of only microfibers in the lake reinforces the textile-related source, suggesting that other types of plastic debris are either less common or degrade differently in the lake's calmer environment.

The river, while having an intermediate microplastic count, presents a unique risk profile due to the fragments found. The transport of these fragments downstream means that the pollution is not contained to a single area but can impact a wider ecological system. The nature of river flow can carry microplastics from rural headwaters to more densely populated areas downstream, contributing to a larger regional pollution issue. This necessitates a broader, more collaborative approach to mitigation that considers the entire river basin, including upstream and downstream communities.

The higher number of microplastics in the pond, at 25 particles, underscores the heightened vulnerability of enclosed or semi-enclosed water bodies. Without a significant outflow to carry pollutants away, microplastics can easily accumulate in the water column and sediment. For rural ponds, potential sources include agricultural runoff carrying plastic mulch particles, atmospheric deposition, and local waste disposal practices. The relatively contained nature of the pond means that any pollution event, however small, can have a more concentrated and long-lasting impact.

The differing types and concentrations of microplastics in each water body have different ecological implications. Microfibers, being highly prevalent and relatively uniform in shape, can be more easily ingested by a wider range of aquatic life, potentially causing digestive blockages or transferring harmful chemicals. Fragments, being more irregular, might pose different physical threats to aquatic organisms depending on their size and sharpness. The varying types also mean that different aquatic species may be more susceptible to different kinds of microplastic harm.

Effective mitigation strategies must be tailored to these site-specific characteristics. For rural ponds and lakes predominantly affected by microfibers, community awareness campaigns focusing on responsible textile washing and disposal are crucial. Providing information on the use of microfiber filters in washing machines or encouraging the use of natural fibers can help reduce the source. For rivers, strategies should focus on preventing macro-plastic litter from entering the waterway in the first place. Cleanup initiatives along riverbanks and improved waste management systems are essential.

Furthermore, municipal authorities and community stakeholders need to understand the interconnectedness of these water bodies. The microplastic pollution in the river, for example, is not solely a problem for that water body but can become a source for downstream ecosystems. This requires a coordinated effort across different jurisdictions that share the same water resources. Education and awareness should not be limited to one community but should be a regional effort, explaining the wider implications of local actions.

The baseline dataset from this study is a critical starting point for ongoing monitoring and assessment. Future studies can use this data to track changes in microplastic concentration and composition over time, evaluating the effectiveness of any mitigation measures that are implemented. This long-term monitoring is essential for understanding the dynamic nature of microplastic pollution in rural water bodies.

For the lake, given the lower initial contamination, mitigation efforts can focus on prevention and protecting the current state of the ecosystem. This might involve stricter controls on fishing gear and promoting environmentally friendly recreational activities. In contrast, the pond, with its higher concentration, may require more intensive cleanup and remediation efforts, in addition to addressing the initial sources. These targeted approaches are more likely to be successful and cost-effective than a one-size-fits-all solution.

For the river, the focus should be on upstream source reduction to prevent the flow of plastics downstream. This could involve working with rural communities and industries to improve waste management and reduce littering. Addressing agricultural runoff, particularly from the use of plastic mulches, is also critical in mitigating microplastic input from non-point sources.

In addition to reducing inputs, developing and implementing innovative technologies for microplastic removal could be part of the long-term solution. While current technologies are often costly, investment in research and development could lead to more affordable and scalable solutions suitable for rural settings. Public-private partnerships could facilitate the deployment of these technologies in conjunction with community-led initiatives.

Finally, the data suggests that rural areas, despite their often-perceived pristine nature, are not immune to the widespread problem of microplastic pollution. The sources may differ from those in urban environments, but the ecological risk is just as real. This highlights the need for dedicated research and policy attention on microplastic contamination in rural settings to inform effective environmental protection strategies.

In summary, the study's findings reveal a complex picture of microplastic pollution in rural water bodies, with each ecosystem having a unique profile of contamination. The higher concentration and microfiber dominance in the pond, along with the fragment presence in the river, demand tailored, site-specific interventions. These must involve a combination of community engagement, improved waste management, and potentially targeted technological solutions, all guided by the baseline data and future monitoring efforts.

VI. CONCLUSION

My research reveals that microplastic contamination is a pervasive issue across all three rural water bodies, but with significant variation in abundance and composition tied to their distinct environmental characteristics and surrounding human activity. The pond, a smaller and more enclosed ecosystem, exhibited the highest concentration of microplastic particles, likely due to reduced water flow and dilution, making it a "hotspot" for accumulation. The dominance of microfibers in both the lake and the pond points towards common sources such as synthetic textiles from domestic or agricultural runoff. In contrast, the river showed a unique pollution signature, with fragments being the predominant type, suggesting that mechanical breakdown of larger plastics is a major process in this dynamic, flowing system. This difference in microplastic type underscores that pollution sources are specific to each environment and not uniform across the rural landscape.

The contrasting microplastic profiles have critical implications for ecological risk and management strategies. The high concentration and distinct nature of microplastic contamination in the pond, particularly the microfibers that can be easily ingested by a wide array of aquatic life, pose a concentrated threat to local biodiversity. For the river, the prevalence of fragments suggests a continuous transport of plastic debris from upstream sources, meaning that mitigation efforts must address a wider geographical area and include upstream communities. The transport dynamics in the river, where plastics move from sources to sinks, highlights the interconnectedness of water systems and the potential for a localized problem to become a regional issue. Meanwhile, the lake, with its larger volume, demonstrates a dilution effect, but the presence of microfibers still indicates ongoing contamination that needs attention.

Addressing microplastic pollution in these rural environments requires a multi-pronged approach tailored to each specific water body. For the pond, the focus should be on local interventions to prevent microfiber release, such as community education on textile care and responsible waste disposal. The river necessitates a broader, upstream-to-downstream strategy to manage macro-plastic waste and its breakdown into fragments. This might involve riverbank clean-up initiatives and improved waste management along the entire river network. For all sites, baseline monitoring is crucial for assessing the effectiveness of interventions and tracking changes in pollution over time.

The data highlights the vulnerability of seemingly pristine rural water bodies to microplastic contamination, challenging the misconception that plastic pollution is solely an urban problem. The rural setting, with its specific land use patterns like agriculture and domestic runoff, contributes uniquely to the microplastic load. For instance, agricultural films or wastewater from homes can introduce microfibers and fragments into local water sources. Therefore, effective strategies must consider these rural-specific inputs and the potential for long-range transport of microplastics through atmospheric deposition, as demonstrated by findings in even remote areas.

The study also reinforces the importance of standardizing monitoring and research protocols, particularly for comparing data across different water bodies and regions. Factors like seasonality, water flow, and sample location can significantly influence microplastic abundance and distribution. By accounting for these variables, future research can provide more reliable and comparable data, which is essential for understanding the true scale of microplastic contamination and developing targeted interventions.

From a broader policy perspective, the findings support calls for stronger regulations on plastic production and waste management at both local and national levels. Policies banning single-use plastics and microbeads have proven effective in reducing specific sources, but broader measures are needed to address textile shedding and the breakdown of larger plastics. The implementation of Extended Producer Responsibility (EPR) frameworks could also incentivize companies to design more sustainable products that are less prone to breaking down into microplastics.

On a community level, public awareness campaigns are a low-cost, high-impact tool for fostering behavioral change. By educating rural communities about the sources of microplastic pollution and providing clear, actionable steps for reduction, such as responsible washing practices and waste disposal, significant progress can be made. Citizen science initiatives can further empower local stakeholders to participate in monitoring and clean-up efforts, fostering a sense of collective ownership over the health of their water bodies.

In terms of ecological restoration, interventions should go beyond simply removing visible plastic debris. For water bodies with high microplastic accumulation, strategies may need to consider more intensive remediation efforts. This could include developing innovative technologies for microplastic removal from both the water column and sediments, while prioritizing sustainable and cost-effective methods suitable for rural applications.

The findings also highlight the need for further research into the long-term ecological and human health impacts of microplastic ingestion. While microfibers are easily consumed and have been shown to cause harm, more needs to be understood about the effects of fragments, and how the chemical additives and adsorbed contaminants associated with microplastics impact aquatic life. Closing these knowledge gaps will be crucial for a comprehensive risk assessment and for developing more effective mitigation strategies.

Ultimately, the study serves as a stark reminder that no ecosystem is truly immune to plastic pollution. Rural water bodies, despite their distance from industrial hubs, are part of a larger, interconnected system and are affected by both local and regional sources. Effective solutions require a holistic approach that integrates robust scientific monitoring, targeted mitigation strategies, proactive policy interventions, and widespread public engagement.

In conclusion, this study provides valuable baseline data on the nature and extent of microplastic contamination in rural water bodies, laying the groundwork for future action. The varying abundance and composition of microplastics across the lake, river, and pond underscore the need for tailored strategies that address site-specific pollution sources and transport mechanisms. By combining targeted mitigation efforts with broader policy changes and public awareness initiatives, it is possible to reduce microplastic input and protect these vital rural ecosystems for future generations. The path forward is a collaborative one, involving researchers, policy makers, and local communities, all working together to tackle this pervasive environmental threat.

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