

Ubiquitous microplastics detection in mosquitoes from urban and rural regions signals a widespread pollution threat – the unseen carriers of hazard

Zahra Rousta

Student Research Committee, Department of Medical Entomology and Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Masoumeh Amin

Department of Medical Entomology and Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Saeed Shahabi

Research Center for Health Science, Department of Environmental Health Engineering, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Amin Hosseinpour

Department Entomology and Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Shahin Saeedi

The student research Committee, Department of Medical Entomology and Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Soheil Oftade

Student Research Committee, Department of Entomology and Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Saba Hashemi-Afzal

Student Research Committee, Department of Medical Entomology Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

Zahra Derakhshan

Research Center for Health Science, Department of Environmental Health Engineering, School of Health, Shiraz University of Medical Science, Shiraz, Iran

Aboozar Soltani

sara.environmental.eng@gmail.com

Research Center for Health Sciences, Institute of Health, Department of Medical Entomology and Vector Control, School of Health, Shiraz University of Medical Sciences, Shiraz, Iran

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Abstract

This study is the first to quantify the prevalence of microplastics in field-collected mosquito larvae across distinct species in Shiraz, Iran, and to assess potential bioaccumulation risks, providing insights into the ecological impacts of MPs. Using a stratified sampling approach, 721 mosquito larvae were collected from six locations in Shiraz. The MPs were characterized by optical microscopy and Raman spectroscopy, focusing on their quantity, size, morphology, and polymer type. Of the five representative mosquito species collected (*Culex pipiens*, *Culiseta alaskaensis*, *Culex pusillus*, *Culex vagans*, and *Culex bitaeniorhynchus*), all specimens selected at random tested positive for MPs, which were predominantly white (81%) and black (84%). Polyethylene was the most encountered polymer, especially in *Culex pipiens* and *Culex pusillus*, comprising 52.81% and 25.84% of the total MPs, respectively. These findings not only highlight the ubiquity of MPs in freshwater ecosystems but also suggest potential bioaccumulation risks within food webs. Given the environmental and health implications of MP contamination, further research is necessary to explore the ecological effects of MPs on mosquito vectors, and their capacity for pathogen transmission.

1. Introduction

Plastics play a pervasive role across various facets of human existence, from food packaging and household items to medicine and electronics (Andrady, 2015). Nevertheless, their extensive utilization, affordability, and ineffective waste disposal practices have led to their release into the environment. Under these conditions, they can break down into microplastics (MPs) ranging from 1 μm to 5 mm and even smaller particles (nanoplastics, NPs) that are less than 1 μm (Barnes et al., 2009; Gigault et al., 2018). Although MPs are found in nearly all environments, from soil and groundwater to the atmosphere, surface water is one of the primary repositories of MPs on Earth (Ricciardi et al., 2021; Rochman and Hoellein, 2020). Numerous aquatic animals ingest MPs, mistaking them for food particles or consuming them passively, resulting in the entry of plastics into food chains (Lehel and Murphy, 2021; Li et al., 2021; Pironti et al., 2021). Until recently, the bioaccumulation of MPs by aquatic organisms has primarily been recognized in marine species. Currently, MPs are found in freshwater organisms at nearly all trophic levels (Gallitelli et al., 2021; Miloloža et al., 2020; Parker et al., 2021), and evidence of their accumulation and biomagnification in freshwater food webs has been reported (Krause et al., 2021; Szymańska and Obolewski, 2020).

Mosquitoes (*Diptera: Culicidae*) are blood-sucking insects and vectors of diseases in wild animals and humans, such as yellow fever, dengue, chikungunya, and Zika viruses (Bhatt et al., 2013; Clements, 2012; Dobson and Fofopoulou, 2001). Given the ecological role of mosquitoes and their life cycle bridging aquatic and terrestrial environments, they represent a crucial but underexplored vector through which MPs could influence broader ecological dynamics and potentially human health, warranting focused investigation of their interactions with MPs during their larval stages. Despite their ecological impact, studies on MPs in mosquito larvae in their natural freshwater habitats remain scarce. In Iran, the available literature primarily focuses on mosquito fauna, larval habitats, and ecological factors in various regions (Azari Hamidian et al., 2011; Nikookar et al., 2016). An interesting contradiction is that while most papers discuss natural breeding sites, Doosti et al. (2021) mention artificial habitats, such as discarded tires, as breeding grounds for *Culex pipiens* in southern Iran (Doosti et al., 2021). Even globally, only Griffin et al. (2023) have studied the link between MPs and mosquitoes and found that polyethylene microplastics increased early instar larval mortality in *Aedes albopictus* and *Culex quinquefasciatus*, with different effects observed at low concentrations between the two species (Griffin et al., 2023).

Mosquitoes can affect the circulation of MPs and NPs in the environment by transmitting fine particles through the transmission networks of vector pathogens. Additionally, mosquitoes are invertebrates that undergo their early stages in water but their adult stages on land, enabling them to transport MPs between aquatic and terrestrial environments. This has also been observed in *Culex pipiens* (Dadd, 1971). and *Ae. aegypti*, *Anopheles albimanus*, *Anopheles quadrimaculatus*, and *Culex quinquefasciatus* mosquito filter-feeding larvae ingested latex microspheres (Aly, 1988). Recently, evidence of the ontogenic transmission of MPs in *Culex* mosquitoes has been reported. *Culex* mosquito larvae have ingested fluorescent polystyrene beads. The 2 μm particles were readily transferred between life stages that utilize distinct habitats: from the

larval to pupal stage and then to the adult terrestrial stage (Al-Jaibachi et al., 2018, 2019). Quantifying such transport would be highly beneficial for modeling the global cycling processes of MPs.

Microplastics can be directly or indirectly ingested by aquatic organisms at various feeding levels and transferred along aquatic food chains, thereby affecting their activities. Additionally, microplastics can adsorb various environmental chemical pollutants and release toxic plastic additives, thereby serving as reservoirs and sources. Specifically for mosquitoes, MPs may affect larval development and survival by altering the nutritional quality of the aquatic environment. Mosquito larvae depend on organic matter and microorganisms for food; therefore, microplastics can disrupt feeding patterns or reduce nutrient availability (Barreaux et al., 2016; Carvajal-Lago et al., 2021; Girard et al., 2021). Nutritional stress during larval stages can affect adult mosquito traits such as body size, longevity, and vector competence, which are vital for disease transmission (Barreaux et al., 2016; Carvajal-Lago et al., 2021). Microplastics may also affect the microbial communities in larval habitats. Because microorganisms are crucial for mosquito development and oviposition site selection (Girard et al., 2021), changes in microbial composition due to microplastics could indirectly affect mosquito populations and distribution. However, understanding the true potential risks of microplastics and related chemical pollutants (such as hydrophobic organic pollutants, heavy metals, and plastic additives) to various organisms, particularly mosquitoes, requires separate, specific, and thorough investigation.

Finally, Shiraz presented a series of characteristics that made it an interesting case study. Climate and environmental factors play crucial roles in mosquito abundance and transmission of contaminants or diseases. Areas with favorable climatic conditions for mosquito breeding and survival, such as moderate temperatures, adequate rainfall, and suitable vegetation, are critical (Ferraguti et al., 2024). The Mediterranean climate of Shiraz provides interesting insights into mosquito ecology and disease dynamics. Furthermore, urbanization and land-use changes can significantly affect mosquito populations. A region undergoing rapid urbanization, such as Shiraz, offers opportunities to study how these changes affect mosquito habitats and disease-transmission patterns (Wang et al., 2020). Hence, it is a valuable location for studying the complex interactions between climate, urbanization, and mosquitoes, even before introducing the issue of MPs. Shiraz has often experienced surges of vector-borne diseases such as malaria, dengue, or West Nile virus (Gheibi et al., 2023; Soltan-Alinejad and Soltani, 2021), making it a valuable location for studying the complex interactions between climate, urbanization, mosquitoes, and disease transmission (Zhang et al., 2024), even before introducing the issue of MPs.

Based on a literature review, no studies have been conducted on the isolation of microplastics from mosquito populations in Iran, and only one has been conducted so far in total. This study provides the first detailed investigation of microplastics in mosquito larvae in Iran, contributing important baseline data to the growing global understanding of microplastics pollution. By documenting the presence of microplastics in freshwater mosquito habitats, which are key components of both local and global food webs, our findings highlight the need for continued attention to this emerging environmental issue. While focusing on a specific region, this study offers insights that may inform broader efforts to understand and mitigate the effects of microplastics on ecosystems worldwide. These results underscore the importance of further research into the pathways through which microplastics interact with terrestrial and aquatic ecosystems.

2. Materials and Methods

2.1. Study area

The Fars Province is located in southern Iran. The province covers an area of 122,608 square kilometers and includes 23 cities. The southern regions of the province are part of the Oriental region, while the northern regions are part of the Palearctic region. Shiraz is one of the five important metropolises in Iran and serves as the capital of the Fars Province. It is located in the palearctic region of the country. Six diverse aquatic habitats in various parts of Shiraz County were selected for mosquito larval collection (Fig. 1). These locations included the campus of the Faculty of Health, Khosh River, Deh Shikh, Farzanegan District, Mianrud, and Dasht Arjan. Table 1 lists the coordinates and descriptions of the larval habitats at the

sampling stations (Table 1). The geographical coordinates of the localities for sampling mosquitoes were obtained using the GPS Status 9.0.183 PRO mobile application and recorded in relevant forms.

Table 1
Coordinates and descriptions of larval habitats.

<i>Sampling location name</i>	<i>Description of habitat/environment</i>	<i>Coordinates</i>
<i>Faculty of Health Campus</i>	Artificial larval habitat (fountain and pond)	29.5929°N, 52.5609°E
<i>Khosh River</i>	A seasonal riverbed that frequently receives municipal wastewater	29.6130°N, 52.5407°E
<i>Deh Shikh</i>	A permanent river with relatively clean, flowing water	27.2995°N, 53.2995°E
<i>Farzanegan District</i>	Small breeding places in suburban areas due to the release of household sewage	29.5775°N, 52.4786°E
<i>Mianrud</i>	Scattered breeding sites in suburban areas from the release of household sewage	29.5675°N, 52.5035°E
<i>Dasht Arjan</i>	A busy tourist area with a natural spring habitat that is littered with garbage	29.6597°N, 51.9827°E

2.2. Sampling methods for mosquitoes

Mosquito larvae were captured using dipping methods from April to December 2023. All the 721 collected mosquitoes were then transferred to the entomology laboratory for identification, and detailed geographic, climatic, and environmental characteristics of the sampling sites were recorded (Jaberhashemi et al., 2022). The collected mosquitoes were identified using the classification methods outlined by Harbach in 1985 and Azari-Hamidian and Harbach in 2009 (Azari-Hamidian and Harbach, 2009).

2.3. Assessment of dominance

The dominance level of each species was determined based on the proportion of the specimens within the entire sample. The measure of dominance was categorized into five groups based on percentage representation: eudominant species (ED) (> 30%), dominant species (D) (10–30%), subdominant species (SD) (5–10%), recedent species (R) (1–5%), and subrecedent species (SR) (< 1%) (Jaberhashemi et al., 2022).

2.4. Extraction of microplastics

For the detection of microplastics, 90 larvae (15 from each site) were randomly chosen to represent the larvae at each collection point without bias. Larvae were washed twice with ultrapure water and homogenized using a mortar and pestle by slowly adding 5 mL of 10% KOH. The resulting homogenate was incubated at room temperature for 12 h in a beaker. In the following step, the solution was filtered using 0.45-micron PTFE filter paper. Subsequently, the filters were rinsed with distilled water to eliminate the excess KOH. The filters were then air-dried at room temperature. To prevent contamination, the sample surfaces were shielded with paper during the separation process (Li et al., 2018).

Microplastic components (quantity, dimensions, morphology, and color) were analyzed using an optical microscope. (Abbasi et al., 2019). Additionally, a confocal Raman spectroscopy device (Lab Ram HR model, Horiba, Ltd., Kyoto, Japan) at the central laboratory of Shiraz University was used to identify the microplastic types.

3. Results

A total of 721 mosquito larvae were collected from six locations in Shiraz (Fars Province), southern Iran, between April and December 2023. From the collected samples, 524 mosquito larvae (3rd and 4th instars) were morphologically identified

using valid taxonomic keys.

From these samples, we identified five species, four from the genus *Culex* and one from the genus *Culiseta*, across all the studied locations. Among the collected mosquitoes, the most abundant species (eudominate) were *Cx. pipiens*, which accounted for 46.4% of the total number of mosquitoes collected. *Cs. alaskaensis* was the second most abundant species (dominant species), accounting for 22.3% of the total number of mosquitoes collected. *Cx. pusillus* (18.9%) and *Cx. vagans* (12.2%) were the dominant species and comprised a smaller percentage of the total number of mosquitoes collected. Furthermore, *Cx. bitaeniorhynchus* was a subrecent species with a frequency of 0.2% of all specimens. A summary of the findings is presented in Table 2.

The highest number of observed species in one community was recorded in the Khoshk River, with four of the five species being collected. Dasht Arjan was the second, where three of the five captured species were found. The highest geographical distribution in the study area was associated with *Cx. pipiens*, which were found at five locations. *Cx. vagans* and *Cs. alaskaensis* were present in two and three of the six studied regions, respectively. The lowest distribution was attributed to *Cx. bitaeniorhynchus*, which was only identified in the Khoshk river. Details of their abundance and the dominant species (in parentheses) are presented in Fig. 2.

Table 2

The distribution and abundance of mosquito larvae collected in six sampling locations of Shiraz County in Fars Province, south of Iran, April–December 2023 (ED = Eudominant, D = Dominant, SD = Subdominant, R = Recedent, SR = Subrecent)

Locations									
Species	Mianrud	Dasht Arjan	Campus of the Faculty of Health	Deh Shikh	Khosh river	Farzanegan district	Total	Frequency (%)	Dominance
<i>Cx. pipiens</i>	59	19	-	45	33	87	243	46.4	ED
<i>Cx. vagans</i>	16	27	-	-	-	21	64	12.2	D
<i>Cs. alaskaensis</i>	-	15	62	-	40	-	117	22.3	D
<i>Cx. bitaeniorhynchus</i>	-	-	-	-	1	-	1	0.2	SR
<i>Cx. pusillus</i>	-	-	51	-	48	-	99	18.9	D
Total	75	61	113	45	122	108	524		
Frequency (%)	14.3	11.6	21.6	8.6	23.3	20.6			

Nevertheless, and more importantly, microplastics were found in all species and locations studied (note: herein, we define a microplastic as a piece of a polymer that remained intact after the digestion and washing process and could be detected and its size measured via microscopy). Figure 2 shows the percentage of microplastics found per region and the dominance of the sampled and identified species. The Dasht Arjan sampling point (33%) was followed by the point in the Farzanegan district (26%) and the Deh Shikh and Faculty of Health points, with slight differences (19 – 16%).

Figure 3 shows the number of microplastics detected by color at various sampling locations. White microplastics were the most common, accounting for 52.81% of all detections across all locations. Black microplastics accounted for 25.84% and were found in five of the six locations. Red microplastics were the least frequent (4.49%) and were only detected in *Cx. pipiens* from the Farzanegan District.

Figure 4 illustrates the mean size of microplastics by color at various sampling locations. The largest microplastic was the blue microplastic detected in the *Cs. alaskaensis* from the Koshk River with a mean size of 500 µm. The smallest was a black

microplastic found in the *Cx. pipiens* in Deh Shikh with a mean size of 75 µm.

Figure 5 presents a detailed visual representation of the types of microplastics, and other particles found in mosquito larvae. These images, captured with a stereomicroscope, facilitate a closer examination of the particles in the larval environment, allowing for the differentiation of the various colored plastics.

Table 3 provides a comprehensive overview of the various types of microplastics, along with other identified particles present in mosquito larvae. This data was organized according to mosquito species and sampling locations, allowing for a clear comparison and analysis of the findings across diverse environmental contexts.

Table 3
Classification of microplastics and other identified particles in mosquito larvae, organized by mosquito species and sampling locations

Mosquito species	Sampling locations	Types of MPs and other identified particles in mosquito larvae
<i>Culex Pipiens</i>	Mianrud	Cotton (polymers covered with plastic color), Polyalkenes (Polyethylene)
<i>Culiseta alaskaensis</i>	Dasht Arjan	Mineral (not plastic), Cotton (polymers covered with plastic color)
<i>Culex pusillus</i>	Campus of the Faculty of Health	Cotton (polymers covered with plastic color), Polyalkenes (Polypropylene)
<i>Culex Pipiens</i>	Deh Shikh	Mineral (not plastic), Cotton (polymers covered with plastic color)
<i>Culiseta alaskaensis</i>	Khosh river	Cotton (polymers covered with plastic color)
<i>Culex Pipiens</i>	Farzanegan district	Polyalkenes (Polyethylene)

Among all the particles identified in our study, cotton was the most prevalent, found in all mosquito species and in nearly all locations, except in the Farzanegan district. Polyalkenes were the most frequently detected microplastics in the mosquito larvae (three sites and two species). This finding highlights the prevalence of polyalkenes as significant contaminants present within the sampled mosquito populations. Polyethylene was the most frequently detected microplastic in the Mianrud and Farzanegan districts and was exclusively collected from *Cx. pipiens*. Another microplastic detected was polypropylene, which was found exclusively in *Cx. pusillus* at the Faculty of Health Campus.

4. Discussion

4.1. Overview of mosquito larvae composition and distribution

Our study offers significant insights into the composition and distribution of mosquito larvae, particularly regarding the prevalence of microplastics. *Culex pipiens* was the most abundant species, accounting for 46.4% of the total, followed by *Culiseta alaskaensis* (22.3%). *Culex pipiens* was found in five of the six sampling locations, which is consistent with previous studies on its adaptability to urban and semi-urban environments (Bashar et al., 2016; Krol et al., 2023; Krol et al., 2024; Pernat et al., 2021). The low frequency of *Culex bitaeniorhynchus* (0.2%) suggests that it is sensitive to specific environmental conditions or pollution. These findings highlight the need to understand species-specific responses to environmental factors, especially urbanization and pollution.

4.2. Prevalence and types of microplastics in mosquito larvae

The detection of microplastics in all sampled larvae is alarming, particularly given their detrimental effects on aquatic life (Avio et al., 2017). Our study found that polyalkenes were the most frequently detected microplastics, with polyethylene being notably prevalent in specific districts. The prevalence of polyethylene is significant because it is a major contributor to global microplastic pollution. Our findings align with global observations, where polyethylene is frequently detected in

various ecosystems, underscoring its ubiquity owing to its widespread use and improper disposal (Burelo et al., 2023; Ghatge et al., 2020).

Minerals were detected in only two locations, Deh Shikh and Dasht Arjan, both of which are natural habitats where rainwater serves as the breeding water source. This may explain the presence of these materials in mosquito larvae. Several studies have explored the relationship between water sources and mosquito breeding habitats, with a focus on habitat-specific factors and larval development. They highlight the importance of environmental parameters, such as mineral content, water quality, and the surrounding ecosystem, in influencing mosquito ecology (Kuo et al., 2021; Multini et al., 2021; Orondo et al., 2023; Soltan-Alinejad et al., 2023; Ukubuiwe et al., 2020).

4.2.1. Microplastic color distribution

Research has indicated that the color distribution of microplastics can reveal their sources and types, with specific colors linked to particular consumer products. Transparent and white microplastics are often used as packaging materials, while other colors stem from textiles and other uses (Cverenkárová et al., 2021). Our analysis revealed that white microplastics were the most prevalent, followed by black, blue, and red microplastics. This pattern likely reflects the plastics used in consumer products. Similarly, studies from Lake Taihu, China, have reported a high presence of white microplastics in sediments that are prone to environmental degradation (Huang et al., 2022).

4.2.2. Microplastic size and quantity distribution

White and transparent/translucent microplastics were the most abundant in our study, comprising up to 47% of floating plastic fragments in other studies (Zhao et al., 2022). The proportion of white microplastics increases in smaller pieces (< 5 mm) and farther from coastal sources (> 500 km) (Zhao et al., 2022). Black microplastics were notably more prevalent in urban areas than in rural ones, likely due to fragments from car tires and trash bags (Umlauf, 2019). The percentage of black fragments may also increase because of the fading of other colors over time (Haque et al., 2024). Blue microplastics, especially fibers, are frequently detected and often originate from indigo-dyed textiles, such as denim (Huang et al., 2022). Green, red, and pink microplastics were less common (Huang et al., 2022). Overall, color analysis of microplastics can help identify their sources and facilitate targeted mitigation efforts.

4.3. Impacts of microplastics on mosquito biology

Several studies have examined microplastics in mosquitoes, mainly in laboratory settings, focusing on their effects on the biology, physiology, and behavior of disease-transmitting species. Griffin et al. investigated the impact of microplastic pollution on the survival and development of *Aedes albopictus* and *Culex quinquefasciatus*. Their findings revealed that polyethylene microplastics significantly increased early larval mortality in *Aedes albopictus*, with a 37% mortality rate at the lowest concentration, whereas *Culex quinquefasciatus* showed no significant mortality at this level (Griffin et al., 2023). These results suggest that rising microplastic levels could affect mosquito populations and their role in disease transmission.

The impact of microplastics on mosquito life cycles, especially on vector species, raises concerns about environmental pollution from plastics and their potential effects on mosquito development, behavior, and vector-borne disease transmission (Gandhi et al., 2024). Additionally, studies on the effects of microplastic ingestion on the microbiome of *Aedes albopictus* and *Aedes aegypti* have shown gut damage and altered bacterial and fungal microbiota composition and diversity, possibly influencing their vector competence for disease transmission (Edwards et al., 2023).

4.3.1. Effects of specific microplastics

Research on high-density polyethylene (HDPE), polypropylene (PP), and polystyrene (PS) has revealed varying effects on mosquito body weight, mortality, and metamorphosis rate. Notably, HDPE and PS reduced larval weight while increasing adult weight, whereas PP had no significant effect (Simakova et al., 2024a). Similarly, microplastics and nanoplastics have

been shown to affect pupal survival and reproduction of *Aedes aegypti* and *Aedes albopictus*, and polyethylene microplastics induce biochemical changes (e.g., nutritional deficits and oxidative stress) in freshwater *Culex quinquefasciatus* mosquito larvae, although the long-term implications for mosquito fitness remain unclear (Jones et al., 2024; Malafaia et al., 2020; McConnel et al., 2024).

4.3.2. Role in environmental transport of microplastics

Laboratory studies have demonstrated that mosquito larvae ingest microplastics, which are then transferred to non-feeding pupae and adult mosquitoes. The ingestion of microplastics by mosquito larvae not only points to ecological disruption but also raises concerns about the indirect exposure of higher trophic levels, including humans, to microplastics through mosquito-borne diseases. Such a process could exacerbate the public health challenges associated with environmental pollution and vector-borne diseases (Simakova et al., 2024b).

4.4. Broader ecological and human health implications

Microplastics significantly affect mosquito larvae, particularly through bioaccumulation and food web transfer. Previous studies have shown that microplastics adversely affect aquatic organisms by reducing their growth rates and altering behavior (Çevik et al., 2022; MacLeod et al., 2021; Mvovo, 2021). Our research indicates that mosquito larvae may indicate microplastic pollution in freshwater ecosystems. Future studies should investigate how microplastics affect mosquito larvae and their potential influence on disease transmission. Addressing these interactions requires a multidisciplinary approach incorporating entomology, toxicology, and public health.

4.5. Local environmental factors and mitigation strategies

Local environmental factors, including water quality, habitat type, and pollutant levels, significantly affect the mosquito populations. This study identified microplastics in all sampled species, predominantly polyalkenes and polyethylene, consistent with previous research but varying in habitat and location (Huzortey et al., 2022; Jambeck et al., 2015). Mitigation strategies for microplastic pollution include better waste management, the promotion of biodegradable materials, and raising public awareness. Collaboration among policymakers, scientists, and communities is crucial to reduce contamination and its effects on ecosystems and human health.

5. Conclusions

Our study is the first to document the pervasive presence of microplastics in mosquito larvae across various locales in Iran and one of the few worldwide, revealing a concerning facet of environmental pollution that bridges aquatic and terrestrial ecosystems. The ubiquitous detection of microplastics, predominantly polyethylene, in all examined mosquito species underscores the extensive contamination of freshwater habitats and highlights the potential role of mosquitoes in the bioaccumulation and biomagnification of these pollutants. Particularly alarming is the finding that polyethylene, a widely utilized and disposed polymer, constitutes a sizable proportion of the microplastics detected, hinting at broader issues related to waste management and environmental stewardship.

The predominance of white and black microplastics observed in our study not only reflects the sources and pathways of microplastic pollution, but also raises questions about the visibility, persistence, and ecological impacts of diverse types of microplastics. The variations in microplastic color and size detected across locations further emphasize the need for a deeper understanding of how environmental factors influence the distribution and fate of microplastics.

Beyond immediate ecological concerns, our findings have profound implications for public health given the role of mosquitoes as vectors of disease transmission. The potential of microplastics to function as vectors for pathogens or to influence mosquito vector competence presents an urgent area for future research, wherein the intersection of microplastic pollution, vector biology, and disease transmission dynamics must be thoroughly investigated.

Looking ahead, it is imperative that further multidisciplinary research efforts are aimed at studying the complex interactions between microplastic pollution, mosquito ecology, and public health and to explore the long-term ecological and health impacts of microplastic contamination in freshwater systems. Finally, our study highlights the critical need for enhanced waste management strategies and policies aimed at reducing the plastic pollution at its source. Only concerted global efforts will mitigate the far-reaching consequences of microplastic pollution and safeguard both environmental and human well-being.

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Figures

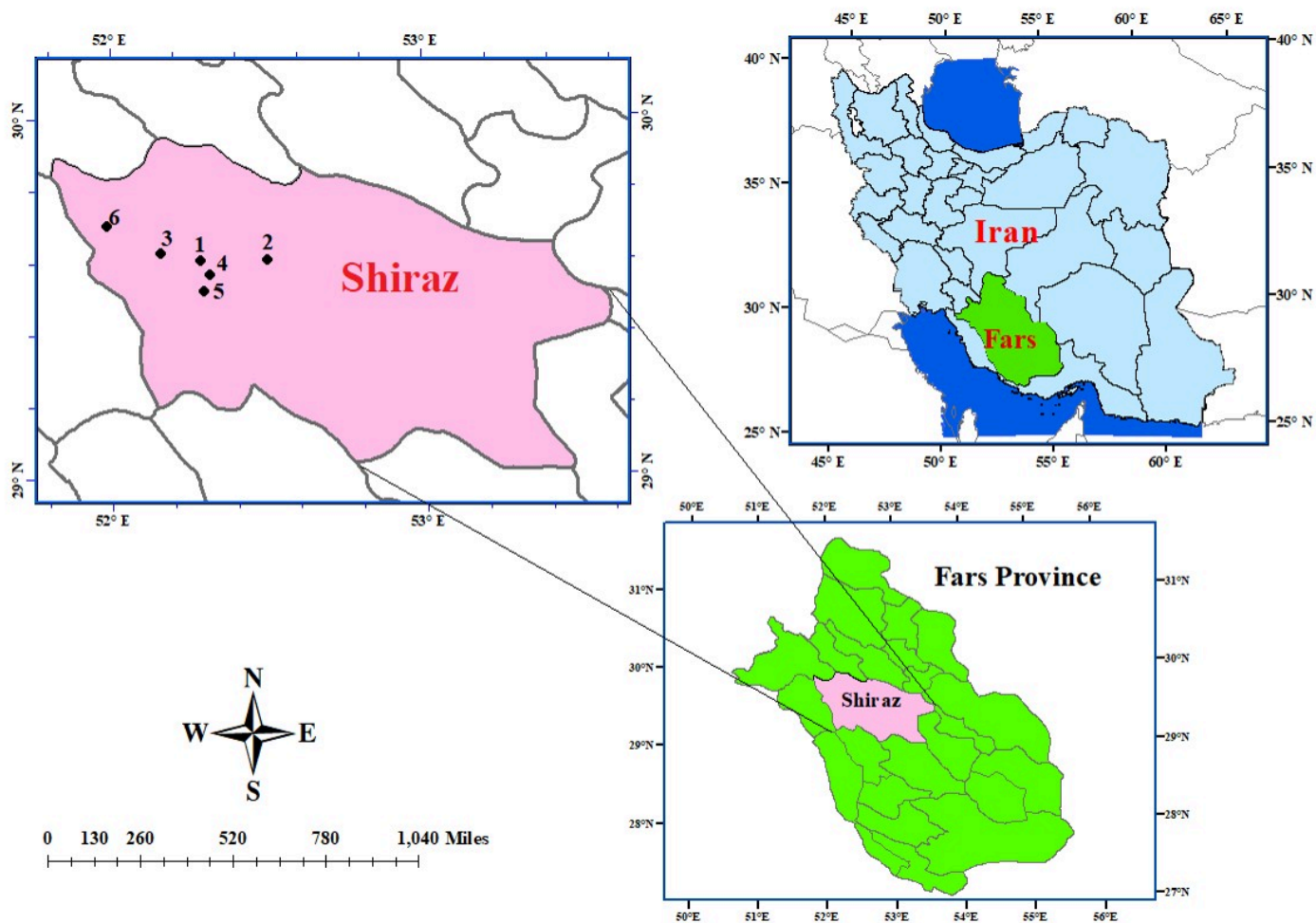


Figure 1

Map of Iran, highlighting the position of Shiraz County in Fars Province, south of Iran, and its six selected locations (Location 1: Campus of the Faculty of Health, Location 2: Khosh river, location 3: Deh Shikh, Location 4: Farzanegan district, Location 5: Mianrud, Location 6: Dasht Arjan) for mosquito sampling during April–December 2023

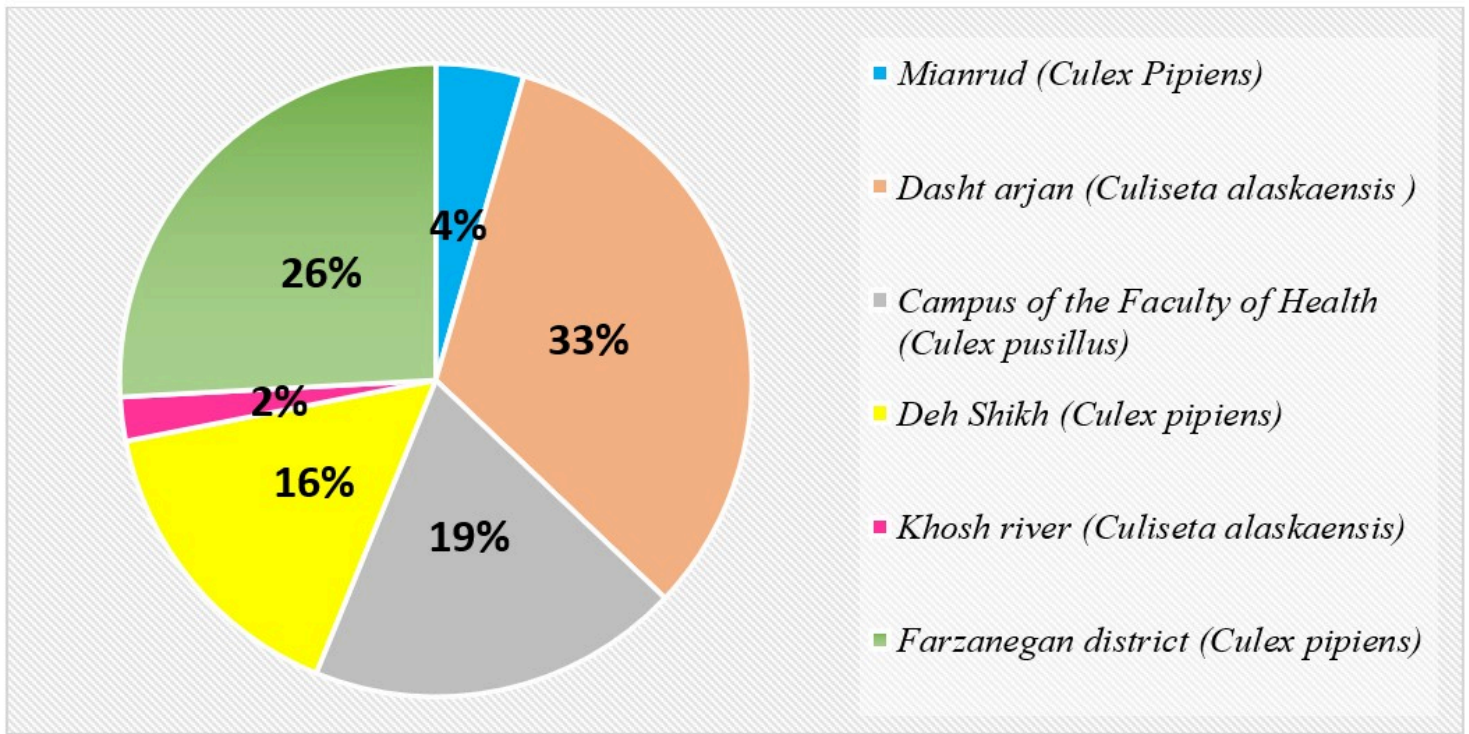


Figure 2

Percentage of detected MPs based on sampling locations/Dominant species of Shiraz County in Fars Province, south of Iran, during the sampling campaign of April–December 2023

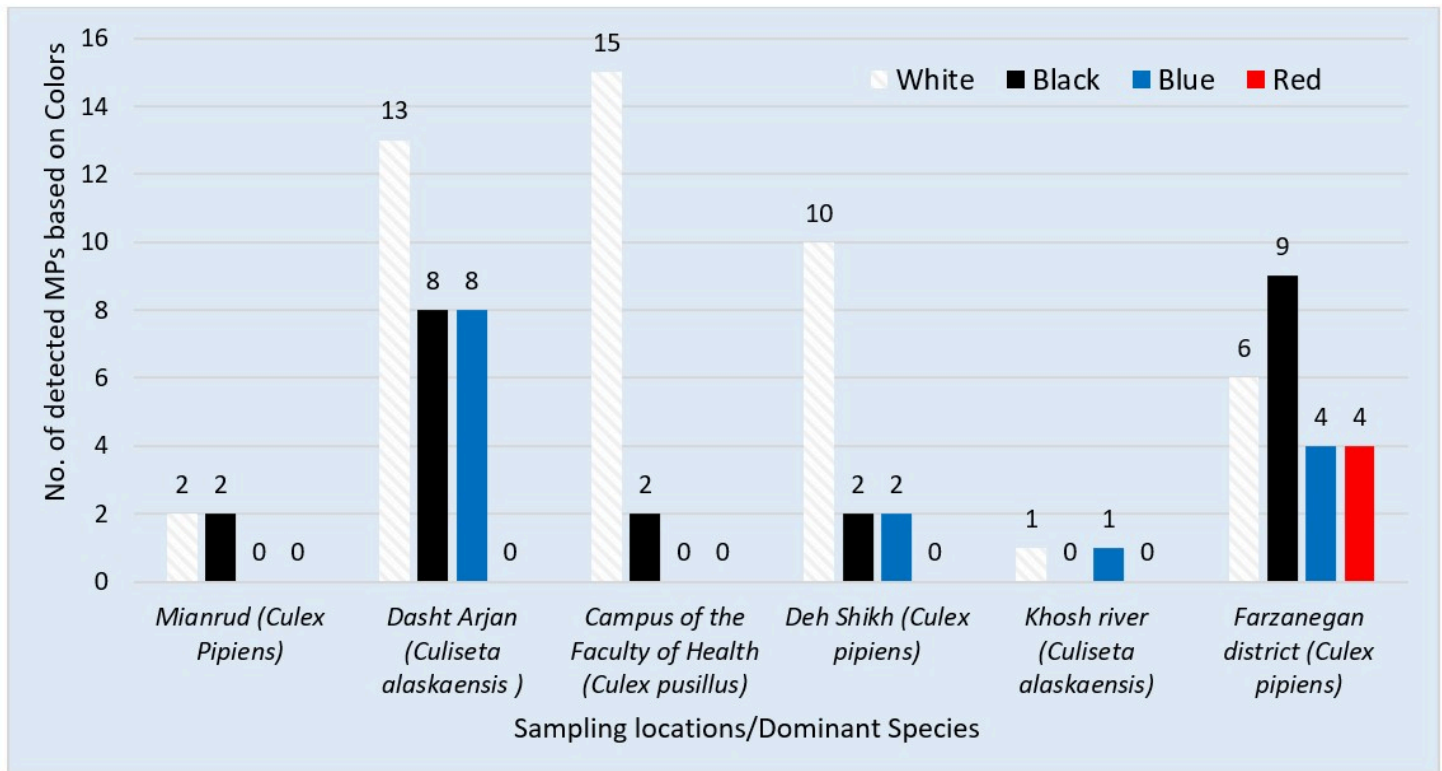


Figure 3

Number of microplastics detected by color

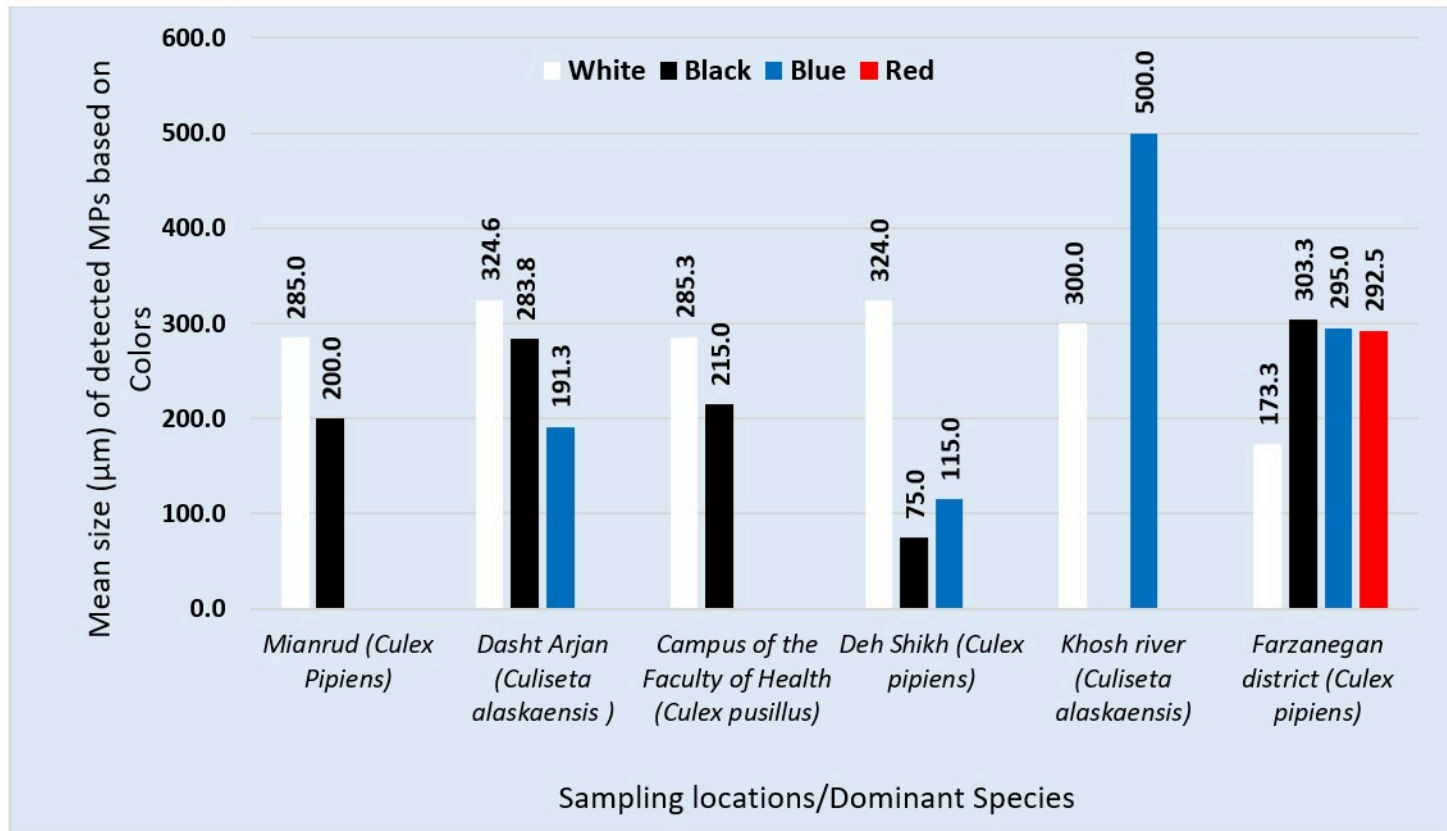


Figure 4

Mean size of MPs by color at various sampling locations

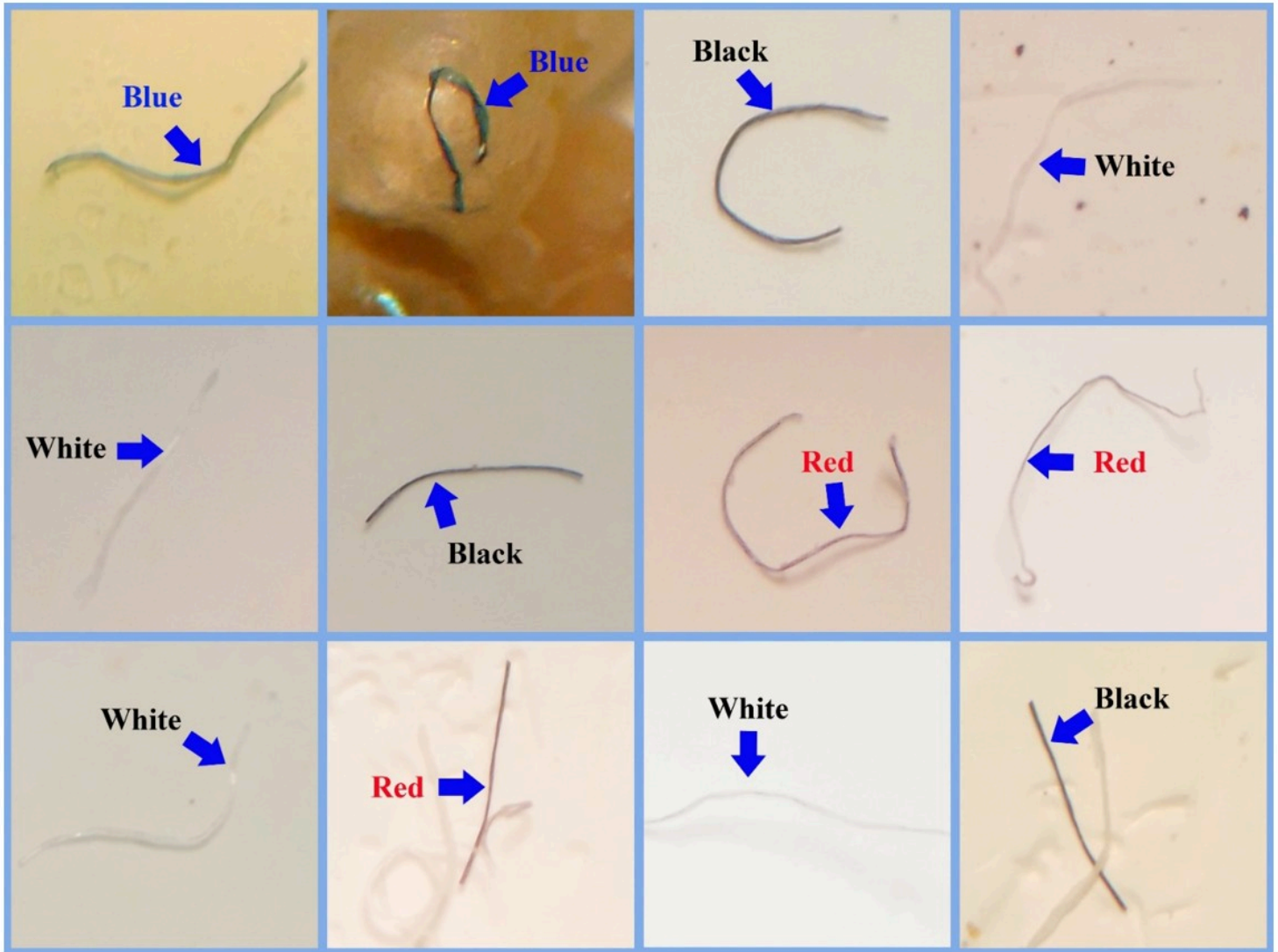


Figure 5

Stereomicroscope images of distinct types of MPs and other identified particles in mosquito larvae.