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Microplastics in the sediments of the middle and upper Lurín River basin, Peru

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ABSTRACT

The objective of this study was to assess microplastic (MP) contamination in sediments in the middle and upper Lurín River basin, Lima, Peru, due to the lack of previous studies on the subject. Surface sediment (SS) and bed sediment (BS) samples were collected at 10 sites along the middle and upper Lurín River basin. In the laboratory, the density separation method using $ZnCl_2$ was used to characterize the MP in the sediment, which was then observed under a microscope. The results show that in both zones (middle and upper basin), the abundance of PM in SS ranged from 222.22 to 922.22 items/kg of dry sediment, and in SL it ranged from 88.89 to 611.11 items/kg of dry sediment. A greater amount of PM was found in SS than in SL. No significant correlation was found between SS and SL. The predominant characteristics in SS and SL were a size of 20 μm –1 mm, a fibrous shape, and a black color. These data will help watershed managers and society improve their understanding of MP pollution in the Lurín River and formulate public policies to improve solid waste management and reduce plastic pollution.

Keywords: microplastics; Peru; bed sediment; surface sediment.

RESUMEN

La presente investigación tuvo como objetivo evaluar la contaminación por microplásticos (MP) en sedimentos en la cuenca media y alta del río Lurín, Lima, Perú, debido a la ausencia de estudios previos sobre el tema. Se recolectaron muestras de sedimento superficial (SS) y sedimento de lecho (SL) en 10 sitios a lo largo de la cuenca media y alta del río Lurín. En laboratorio para caracterizar los MP del sedimento se usó el método de separación por densidad con $ZnCl_2$, y luego fue observado en el microscopio. Los resultados muestran que en ambas zonas (cuenca media y alta) la abundancia de MP en SS estuvo entre 222,22 a 922,22 Ítems/kg de sedimento seco y en SL fue de 88,89 a 611,11 Ítems/kg de sedimento seco. Se encontró una mayor cantidad de MP en SS que en SL. No se mostró correlación significativa entre SS con SL. Las características predominantes en SS y SL fueron el tamaño de 20 μm –1 mm, con forma de fibra y de color negro. Estos datos ayudarán a los gestores de la cuenca y a la sociedad a mejorar la comprensión sobre la contaminación por MP en el río Lurín, y formular políticas públicas para mejorar la gestión de residuos sólidos y reducir la contaminación por plásticos.

Palabras-clave: microplásticos; Perú; sedimento de lecho; sedimento superficial.

Introduction

The increase in plastic production, coupled with current waste disposal practices, leads to an increase in the concentration of plastic particles in the environment (Hossain et al. 2023). This has resulted from the accelerated production of plastic since 1950, when 1.5 Mt was produced (Amelia et al. 2021), up to 400.3 Mt in



Submission: 06/12/2025



Accepted: 21/05/2026



Publication: 18/06/2026



2022 (Plastic Europe 2023). By 2050, this figure will reach 1,124 Mt (World Economic Forum, Ellen MacArthur Foundation, and McKinsey & Company 2016). Therefore, inadequate management and poor disposal of plastic waste can result in it ending up in the environment (Evode et al. 2021), and as it degrades, it forms plastic particles known as microplastics (MP) (Thompson et al. 2004; Castañeda et al. 2020). Various studies show an increase in their presence, as they are found in the oceans, beaches, rivers, and soils of South America and around the world (Rochman 2018).

In response to this problem, interest in researching MP has grown, leading to an increase in publications on the subject over the past two decades (GESAMP 2015). MPs have been defined as plastic particles ranging from 1 μm to 5 mm (Castañeda et al. 2020), and classified by size into 1–5 mm (large MPs) and 1 μm –1 mm (small MPs) (GESAMP 2015; Yoon et al. 2024), and classified by origin as primary (manufactured at the microscopic scale) and secondary, resulting from the physical, chemical, and/or biological degradation of larger plastics (mesoplastics (5–25 mm) and macroplastics (>25 mm) (Hartmann et al. 2019; Castañeda et al. 2020).

Currently, MP are present in river sediments (Shruti et al. 2019; Scherer et al. 2020), lakes, and sandy beaches (Purca & Henostroza 2017; Turner et al. 2019), stormwater (Canchari & Iannacone 2024), irrigation canals (Canchari & Iannacone 2022), and intermittent streams (Canchari & Iannacone 2023). Similarly, MP has been assessed in marine fish and other hydrobiological species (Alfaro-Núñez et al. 2021, Iannacone et al. 2021), in salt for human consumption and in human blood (Jung et al. 2022), in bottled water for human consumption (Hossain et al. 2023), in seawater (Alfaro-Núñez et al. 2021), in air (Chen et al. 2023), in soil (Sajjad et al. 2022), and in clouds (Wang et al. 2023).

Various studies around the world have measured MP in river sediment and water, such as in sediment in the Atoyac River basin, Mexico (Shruti et al. 2019), in sediment from tributaries of the River Thames, United Kingdom (Horton et al. 2016), in sediment from the Negro, Solimões, and Amazon rivers in Brazil (Gerolin et al. 2020), in water and sediment in the Antuã River in Portugal (Rodrigues et al. 2018), in river sediment in the Daliao and Shuangtaizi Rivers, China (Xu et al. 2020), in sediment from the Brisbane River, Australia (He et al. 2019), in sediment in Peru in the Jequetepeque River, La Libertad, Peru (Manrique 2019), in sediment in tributary streams of the Huangáscar River, Peru (Canchari & Iannacone 2024), in water and sediment in the Huallaga, Aucayacu, and Sangapilla rivers in the Huánuco region (Lino 2022), and others.

In the lower Lurín River basin, MP was found in river sediment, attributed to anthropogenic activities in the surrounding area as the primary source of contamination (Martínez et al. 2023), since single-use plastics have been the most commonly found in the lower Lurín River basin (Vélez-Azañero et al. 2022), as the river serves as a direct transport route for plastics and MP to the sea (Martínez et al. 2023). Given this, there is a need to assess MP throughout the basin to understand its distribution and abundance. Therefore, this study aims to assess MP contamination in sediments in the middle and upper basins of the Lurín River, Peru.

Materials and Methods

Spatial and temporal delimitation

The study area corresponds to the middle and upper Lurín River basin, with elevations ranging from 689 m a.s.l. to 3,254 m a.s.l., encompassing the sampling sites. It is located in the central-western region of Peru, where there is a high concentration of populated centers adjacent to the Lurín River (Figure 1). The Lurín River basin covers an area of 1,642.52 km², and has a main channel length of 110.84 km, with elevations ranging from 0 to 5,300 m a.s.l. and precipitation ranging from 0 to 35.73 mm/year (lower basin), 27.69 to 77.92 mm/year (middle basin), and 277.16 to 627.6 mm/year (upper basin) (ANA 2019). This basin is one of the most densely populated in Peru (Momb Blanch et al. 2015), with solid waste being one of the main sources of pollution in the



Lurín River (Vélez-Azañero et al. 2022). The average flow rate is 4.62 m³/s, with the highest water volume occurring from January to April, accounting for 84.86% (ANA 2019). The study was conducted in September 2023.

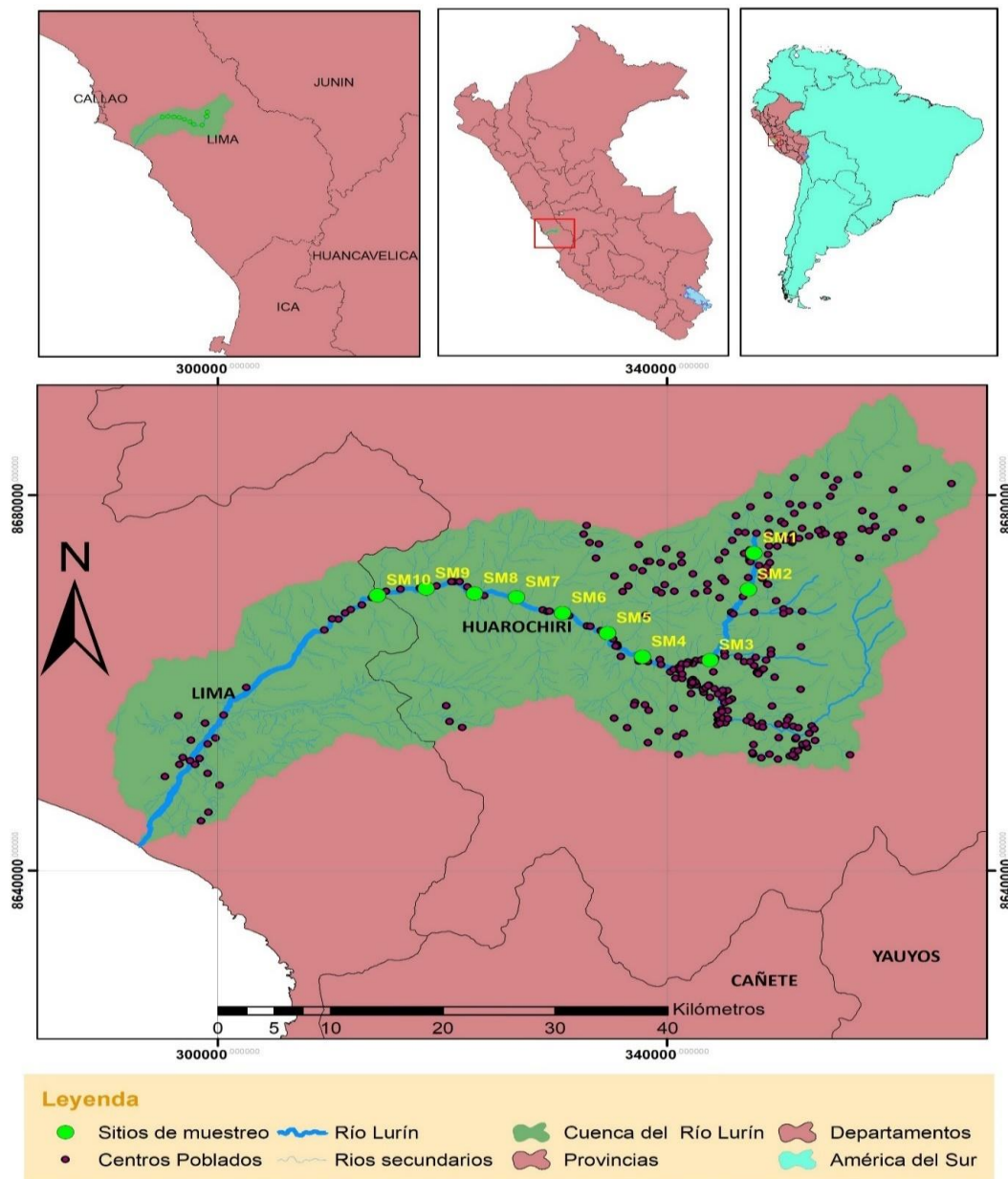


Figure 1. Location of the study area and sampling sites in the middle and upper basin of the Lurín River, Lima, Peru. Source: Prepared by the authors (2025).

Selection of sampling sites

The 10 sampling sites were selected based on hydrodynamic disturbances caused by settlements with high population densities (Sarkar et al. 2019). Similarly, in the Lurín River basin, many populated areas can be seen near the main river (Figure 1). In addition, site accessibility for sampling was taken into consideration (Shruti et al. 2019). Therefore, ten sampling sites were selected, covering the middle basin (seven sites) and upper basin of the Lurín River (three sites) (Figure 1). Table 1 shows the characteristics of the sampling sites.



Table 1. Characterization of sampling sites in the middle and upper basins of the Lurín River, Lima, Peru.

Sampling site	WGS84 Zone 18S UTM		Characteristics of the sampling sites
	EAST	NORTH	
SM1	347736.3	8673796.6	In the upper basin of the Lurín River (San Damián District) and downstream from a settlement located on the banks of the Lurín River in the San Damián District. Plastic debris was found near the sampling site.
SM2	347250.8	8669940.4	In the upper basin of the Lurín River (San Damián District) and downstream of a tributary—a stream adjacent to the town of San Damián. Plastic waste was observed near the sampling point.
SM3	343831.7	8662387.8	In the upper basin of the Lurín River (Lahuaytambo District). Downstream from the town of La Pedrera and surrounding hamlets. A plastic waste dump was observed 30 m from the sampling site.
SM4	337819.1	8662777.1	In the middle basin of the Lurín River (Antioquia District). Downstream from the tributary—the stream connected to the La Pampilla settlement—macroplastics were observed on the sand.
SM5	334688.6	8665272	In the middle basin of the Lurín River (Antioquia District), downstream from the Antioquia settlement, which has tourism potential. Some plastic waste was found.
SM6	330711.3	8667433.3	In the middle basin of the Lurín River (Antioquia District). The surrounding area features agricultural activity, a few homes, and plastic waste.
SM7	326602.1	8669117.7	In the middle basin of the Lurín River (Antioquia District). Downstream from a populated area with plastic waste and agricultural activity.
SM8	322847.6	8669496.2	In the middle basin of the Lurín River (Antioquia District), downstream from the town of Sisicaya. There is a stream that flows into the Lurín River before the sampling site, where plastic waste was found; plastic was also observed near the sampling site, along with agricultural activity.
SM9	318555.1	8670026.9	In the middle basin of the Lurín River (Antioquia District), downstream from a recreational center. Agricultural development and activities related to riverbank infrastructure () were observed. Presence of plastic waste.



SM10	314229.8	8669324.4	In the middle basin of the Lurín River (Antioquia District), downstream from a recreational center and agricultural development. A landfill was observed on the banks of the Lurín River.
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Source: Prepared by the authors (2025).

Sampling of surface sediment (SS) and bed sediment (SL)

At each sampling site, a transect perpendicular to the river was established, along which surface sediment (SS) samples were collected from the riverbank and riverbed sediment (SL) samples were collected from the riverbed (Manrique 2019).

For SS, samples were collected at each site along the riverbank (Klein et al. 2015), where three SS samples were randomly selected per site and placed in an aluminum foil bag, where they were combined into a composite sample (Wang et al. 2017). Each sample was collected from a surface area of 20 cm x 20 cm x 2 cm in depth using a metal shovel (Manrique 2019; Canchari & Iannacone 2024).

In the case of river SL, which is located below the water column, it was collected 1 m from the riverbank using an Ekman dredge (Razeghi et al. 2021), with which three sediment samples were collected and combined into a single homogenized composite sample for MP analysis. The samples were then placed in aluminum foil bags (Wang et al. 2017) and transported to the Laboratory for Research on Ecology and Animal Biodiversity (LEBA) at the Faculty of Natural Sciences and Mathematics of the Federico Villareal National University, Lima, Peru. Values were expressed in items/kg of dry sediment.

Preparation of sediment samples

The wet sediment samples were placed in 1-L beakers and dried in an oven at 65 °C for 36 h (Sarkar et al. 2019). Then, for each site, 30 g of dry sediment were analyzed in triplicate; these were placed in a 250 mL beaker to which 30% hydrogen peroxide (H₂O₂) (Wang et al. 2017) to a volume of 30 mL and left overnight to remove organic residues. Next, 36 mL of zinc chloride (ZnCl₂) was added to a density of 1.7 kg/L, stirred, and left for 24 h (Shruti et al. 2019). The supernatant was then filtered using Filter-LAB filter paper via a Rocker 400 vacuum pump and transferred to Petri dishes for subsequent analysis (Shruti et al. 2019; Canchari & Iannacone et al. 2024). The pore size of the filter used in this study was 20 µm.

Finally, using a Nikon Type 104c microscope with a camera coupled to Topview software, the MP were observed, counted, and their morphological characteristics were identified (Tibbetts et al. 2018). The abundance and characteristics of the MP were identified according to Table 2.

Table 2. Parameters evaluated for PM in surface sediment (SS) and bed sediment (SL) in the present study

Source	Parameter	Indicator	Reference
Surface and bottom sediment	Abundance	Items/kg of dry sediment	Jiang et al. (2019)
	Color	Transparent, yellow, white, green, red, blue, and black.	Su et al. (2016)
	Form	Pellet, fragment, fiber, film, and foam	Yang et al. (2021)
	Size	1–5 mm (large PM) and 1 µm–1 mm (small PM)	Crawford & Quinn (2016)

Source: Prepared by the authors (2025).



Measures to prevent contamination

Throughout the field and laboratory procedures, no plastic equipment or materials were used, and work was conducted in a laminar flow hood to prevent contamination with other PM such as fibers (Sarkar et al. 2019). The long-sleeved, button-up white lab coats and work clothes used in the laboratory and in the field were made of cotton. Nitrile gloves were used. The various reagents used were filtered in a vacuum system to prevent potential cross-contamination. In the laboratory and in the field, airborne PM contamination was taken into account, so a Petri dish with a moistened filter was placed in the laminar flow hood and at the sampling site (Lin et al. 2018).

Statistical Analysis

The IBM SPSS (Statistical Package for the Social Sciences) V22.0 statistical package was used. The Shapiro-Wilk normality test and Levene's test for homogeneity of variances were performed for the abundance of MP in SS and SL. To examine differences in MP abundance between SS sites, Welch's ANOVA was performed, as the data did not meet the assumption of homogeneity of variances but did meet the assumption of normality. To examine differences in MP abundance between sites in SL, ANOVA with Tukey's post hoc test was performed, as the data met the assumptions of normality and homogeneity of variances. Differences in MP abundance between SS and SL for each site were analyzed using Student's t-test for independent samples, as the MP abundance in SS and SL for each site met the normality and homogeneity of variances assumptions, with the exception of site SM4, which did not meet the assumption of homogeneity of variances; therefore, Student's t-test for heterogeneous variances was used. Abundances were considered significantly different at $p < 0.05$ (Xu et al. 2020). Finally, the Spearman correlation coefficient was calculated between MP abundance in SS and SL in the river.

Ethical Considerations

The Institutional Committee on Ethics in Research with Animals and Biodiversity at the Universidad Científica del Sur (CIEI-AB-CIENTÍFICA) approved this research under Certificate No. 074-CIEI-AB-CIENTÍFICA-2023. Permission was requested from the district municipalities of Antioquía, Lahuaytambo, and San Damián, which are located in the middle and upper basin of the Lurín River, Lima, Peru. Furthermore, no hazardous materials that could endanger the environment or people were used in the field. In the laboratory, biosafety standards outlined in the Laboratory Manual were followed in accordance with Resolution No. 7116-2020-UNFV (Federico Villarreal University), and hazardous waste was disposed of according to the protocol for the management of hazardous laboratory waste. In addition, the Material 154 Safety Data Sheets (MSDS) for the chemical compounds used in the laboratory, such as $ZnCl_2$ and H_2O_2 , were taken into account.

Results and Discussion

MP Abundance

The results show sediment contamination by MP at all sampling sites on the Lurín River, both in dry sediment (SS) in the upper basin (sampling sites SM1, SM2, and SM3) with an MP abundance of 277.78 to 566.67 items/kg of dry sediment and in the middle basin (sampling sites SM4, SM5, SM6, SM7, SM8, SM9, and SM10) with a plastic item abundance ranging from 222.22 to 922.22 items/kg of dry sediment (Figure 2a) and both in the upper basin with an MP abundance of 144.44 to 611.11 items/kg of dry sediment and the middle basin with an MP abundance of 88.89 to 277.78 items/kg of dry sediment (Figure 2b). The abundance

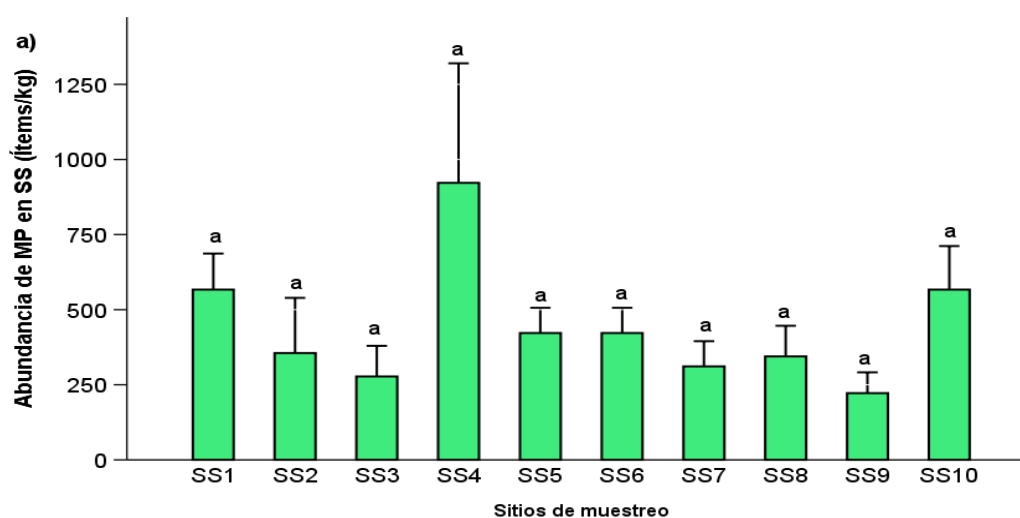


of MP between both zones (middle and upper basin sites) for SS ranged from 222.22 to 922.22 items/kg of dry sediment (of the 10 sites, the mean \pm standard deviation was 441.11 ± 239.52 items/kg of dry sediment) and for SL, it ranged from 88.89 to 611.11 items/kg of dry sediment (of the 10 sites, the mean \pm standard deviation was 233.33 ± 159.01 items/kg of dry sediment) (Figure 2ab).

Figure 2a shows that, for SS, the sampling sites in the upper basin (SM1, SM2, and SM3) did not show significant differences. Likewise, no significant differences were found at the sites in the middle basin (SM4, SM5, SM6, SM7, SM8, SM9, and SM10). The sites in the middle and upper basins did not show significant differences ($p = 0.09$). However, in the lower basin, specifically at the river mouth, the concentration of PM is higher (Martínez et al. 2023), due to the presence of plastics (Vélez-Azañero et al. 2022).

In Figure 2b, for SL, the sampling sites in the upper watershed (SM1 and SM2) did not show significant differences ($p = 0.26$) compared to the other sites in the middle watershed (SM4, SM5, SM6, SM7, SM8, SM9, and SM10). Likewise, the sampling sites in the upper basin (SM1 and SM2) did not show significant differences between them, with the exception of sampling site SM3 (located in the upper basin), which has a higher concentration of MP compared to the other sites ($p = 0.000044$). This higher value could be related to the proximity to a town and a solid waste dump, as other studies indicate that high MP concentrations are associated with the presence of dumps in a river system (Canchari & Iannacone 2024), and directly associated with higher human population density (Manrique 2019) and anthropogenic activities that discharge plastics into the Lurín River basin (Martínez et al. 2023).

The MP concentration is significantly higher in SS compared to SL for sites SM1, SM6, SM7, and SM10; and shows no significant differences at sites SM2, SM4, SM5, SM8, and SM9. However, at site SM3, it is significantly higher in SL than in SS (Table 3). These results are similar to the study by Manrique (2019) conducted in the lower Jequetepeque River basin, which showed three sampling sites with equal MP abundance in SS and SL. However, at a single site, it is higher in SS than in SL. In general, when comparing MP abundance between SL and SS, more MP was found in SS than in SL ($p < 0.05$) (Manrique 2019). This is explained by the fact that there is more disturbance along the riverbanks than in the center of the riverbed (Adomat & Grischek 2021), and there may be potential contamination of surface sediment by atmospheric deposition of MP over time (Napper et al. 2023).



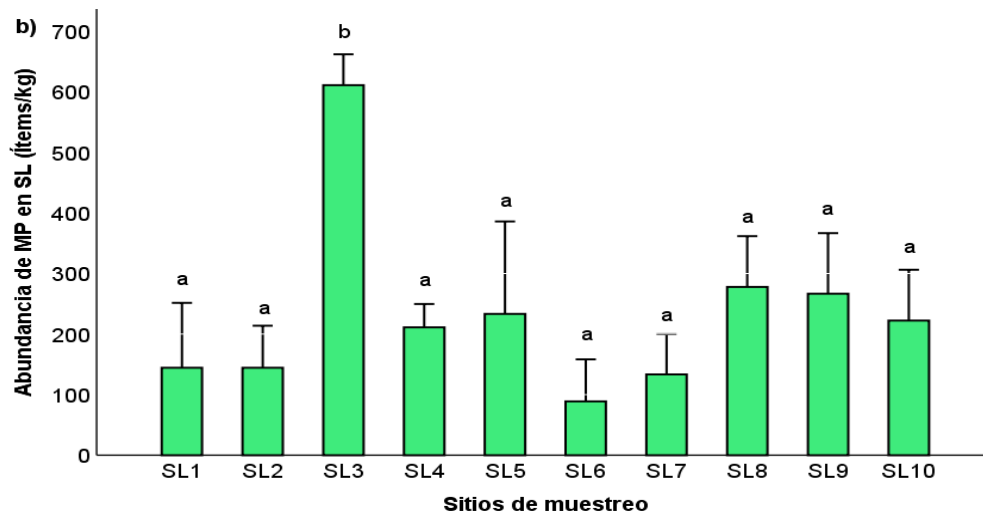


Figure 2. MP abundance (items/kg of dry sediment): a) in surface sediment (SS) and b) in bed sediment (SL) in the Lurín River, Peru. Source: Prepared by the authors (2025).

Table 3. Comparison of microplastic abundance (items/kg of dry sediment) by sampling site in bed sediment (BS) and surface sediment (SS) of the Lurín River, Peru. t = Student's t-test for independent samples. P = probability. SM = Sampling site

Sampling site	SL Abundance	SS Abundance	t	p
SM1	144.44	566.67	4.54	0.01
SM2	144.44	355.56	1.86	0.13
SM3	611.11	277.78	5.07	0.007
SM4	211.11	922.22	3.08	0.08
SM5	233.33	422.22	1.87	0.13
SM6	88.89	422.22	5.30	0.006
SM7	133.33	311.11	2.87	0.04
SM8	277.78	344.44	0.87	0.43
SM9	266.67	222.22	0.63	0.56
SM10	222.22	566.67	3.55	0.02

Source: Prepared by the authors (2025).

Spearman's correlation analysis showed that there is no association between the abundance of MP in SL and SS ($Rho = -0.39$; $p = 0.25$). Similarly, in the Jequetepeque River, no correlation was found when analyzing data from both types of sediment (SL and SS) (Manrique 2019).

The abundance of MP in SS in the Lurín River shows maximum values comparable to those reported in the Beijiang River, China (Wang et al. 2017), in rivers of the Tibetan Plateau, China (Jiang et al. 2019), and in the Zayandeh-Rud River, Iran (Rami et al. 2023). However, these maximum values are lower than those recorded in the Ishoj and Uyrú Rume streams, Peru (Canchari & Iannacone 2024) (Table 4). On the other hand, the SL in this study shows maximum values higher than those of the Zahuapan and Atoyac rivers in Mexico (Shruti et al. 2019), the Brisbane River in Australia (He et al. 2019), and the Krukut River in Indonesia (Azizi et al. 2022). However, they are lower than those found in the Vaal River, South Africa (Ramaremsa et al. 2022), the Antuã River, Portugal (Rodrigues et al. 2018), and the Amazon, Negro, and Solimões Rivers, Brazil (Gerolin et al. 2020) (Table 4).

MP contamination has been detected in various coastal rivers in Peru; in sediments in the lower basin of the Chillón River (Martínez et al. 2023), in the Jequetepeque River basin (Manrique 2019), and in the Rímac



River (Huanaco & Gamboa 2023). Furthermore, not only has MP contamination been identified in river sediments in these Peruvian basins, but MP has also been found in SS and SL in rivers in different parts of the world (Table 4).

Table 4. Studies of MP in river/stream sediments from different countries.

River/stream	Country	Sediment type	MP abundance (Items/kg)	References
Lurín River (middle and upper basin)	Peru	SS	222–922	This study
	Peru	SL	89–611	This study
Vaal River	South Africa	SL	29–1100	Ramaremissa et al. (2022)
Krukut River	Indonesia	SL	112–150	Azizi et al. (2022)
Antuã River	Portugal	SL	18–629	Rodrigues et al. (2018)
Brisbane River	Australia	SL	10–520	He et al. (2019)
Zahuapan River	Mexico	SL	66.67–400	Shruti et al. (2019)
Atoyac River	Mexico	SL	100–400	Shruti et al. (2019)
Negro River	Brazil	SL	5869–8178	Gerolin et al. (2020)
Amazon River	Brazil	SL	417 – 2101	Gerolin et al. (2020)
Solimões River	Brazil	SL	1524–1738	Gerolin et al. (2020)
Jequetepeque River (Lower Basin)	Peru*	SL	0–20	Manrique (2019)
		SS	0–160	Manrique (2019)
Rímac River (lower basin in 2017 and 2018)	Peru*	SS	0–139.9	Huanaco & Gamboa (2023)
		SS	43.3–5,756	
Beijiang River	China*	SS	178–544	Wang et al. (2017)
Rivers of the Tibetan Plateau	China	SS	50–195	Jiang et al. (2019)
Zayandeh-Rud River	Iran	SS	0–67.3	Rami et al. (2023)
Ishoj Creek	Peru	SS	0 – 2216	Canchari & Iannacone (2024)
Uyru Rume Ravine	Peru	SS	0–6383	

SS: surface sediment, SL: bed sediment; all these studies used high-density $ZnCl_2$ saline solution, with the exception of *, which used NaCl. Source: Prepared by the authors (2025).

MP characteristics

Size

The predominant particle size range at SS (58.94%) and SL (54.29%) was 20 μm –1 mm, compared with the 1–5 mm range (Figure 3; Table 5). For SL, the PM size range of 20 μm –1 mm was predominant at most sites, with the exception of SM1, SM2, SM7, and SM9, which had a PM size range of 1–5 mm. At the watershed level, for SS, the PM size range of 20 μm –1 mm was predominant in the upper (59.3%) and middle (58.8%) watersheds. Similarly, for SL, the MP size range of 20 μm –1 mm was predominant in the upper (59.3%) and middle (51.2%) basins (Figure 3).

These results, showing a higher percentage of PM sizes in the 20 μm –1 mm range, are similar to those found for SS in the Ishoj and Uyru Rume streams, Peru (Canchari & Iannacone 2024), in SS from the Zayandeh-Rud River, Iran (Rami et al. 2023), in SS from rivers on the Tibetan Plateau, China (Jiang et al.



2019), in SS from the Rímac River, Peru, in the August sampling (Huanaco & Gamboa 2023), Likewise, sizes of 20 μm –1 mm were higher in SL in the Negro and Solimões rivers, Brazil (Gerolin et al. 2020), and in the Vaal River, South Africa (Ramaremsa et al. 2022). In contrast, in the SL in the Amazon River, PM of 1–5 mm in size was more abundant (Gerolin et al. 2020). However, comparing PM size ranges with other studies proves challenging due to differences in sieve sizes and classification methods (Rami et al. 2023).

Assessing the size range of MP (20 μm –1 mm and 1–5 mm) in SS and SL in this study is important because MP toxicity depends on its size (Lei et al. 2018). Sediments act as sinks for small-sized MP, and the abundance of MP by size range is influenced by environmental degradation processes (Ramaremsa et al. 2022), as MP are susceptible to fragmentation under environmental conditions, leading to a higher abundance of small-sized MP (Egessa et al. 2020). Gravity, buoyancy, and transport influence MP size and affect accumulation in sediments (Du et al. 2021; Shamskhany et al. 2021). Therefore, it is suggested that smaller MP (1–20 μm) be detected in the sediments of the Lurín River, Peru.

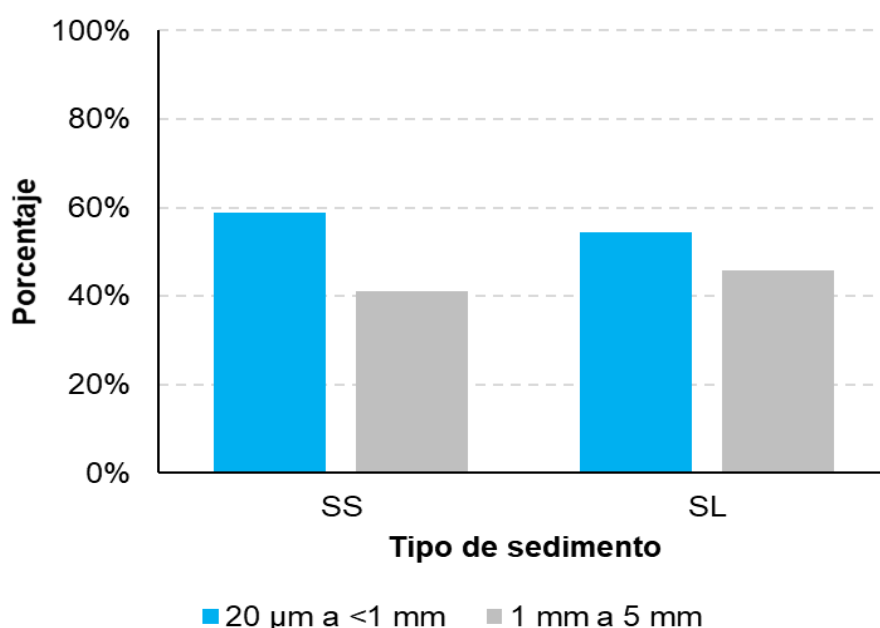


Figure 3. Percentage of MP by size range of total MP in the middle and upper basin, for both SS and SL. Source: Prepared by the authors (2025).

Table 5. Number (items/kg) and percentage (%) of microplastics by size range per sampling site in surface sediment (SS) and bed sediment (SL) in the Lurín River, Lima, Peru.

Sediment type	Sampling site	MP by size range			
		20 μm –1 mm		1–5 mm	
		items/kg	%	items/kg	%
SS	SM1	277.8	49.0	288.9	51.0
	SM2	200.0	56.3	155.6	43.8
	SM3	233.3	84.0	44.4	16.0
	SM4	533.3	57.8	388.9	42.2
	SM5	300.0	71.1	122.2	28.9
	SM6	222.2	52.6	200.0	47.4
	SM7	177.8	57.1	133.3	42.9



	SM8	155.6	45.2	188.9	54.8
	SM9	100.0	45.0	122.2	55.0
	SM10	400.0	70.6	166.7	29.4
SL	SM1	55.6	38.5	88.9	61.5
	SM2	66.7	46.2	77.8	53.8
	SM3	411.1	67.3	200.0	32.7
	SM4	144.4	68.4	66.7	31.6
	SM5	133.3	57.1	100.0	42.9
	SM6	44.4	50.0	44.4	50.0
	SM7	55.6	41.7	77.8	58.3
	SM8	144.4	52.0	133.3	48.0
	SM9	66.7	25.0	200.0	75.0
	SM10	144.4	65.0	77.8	35.0

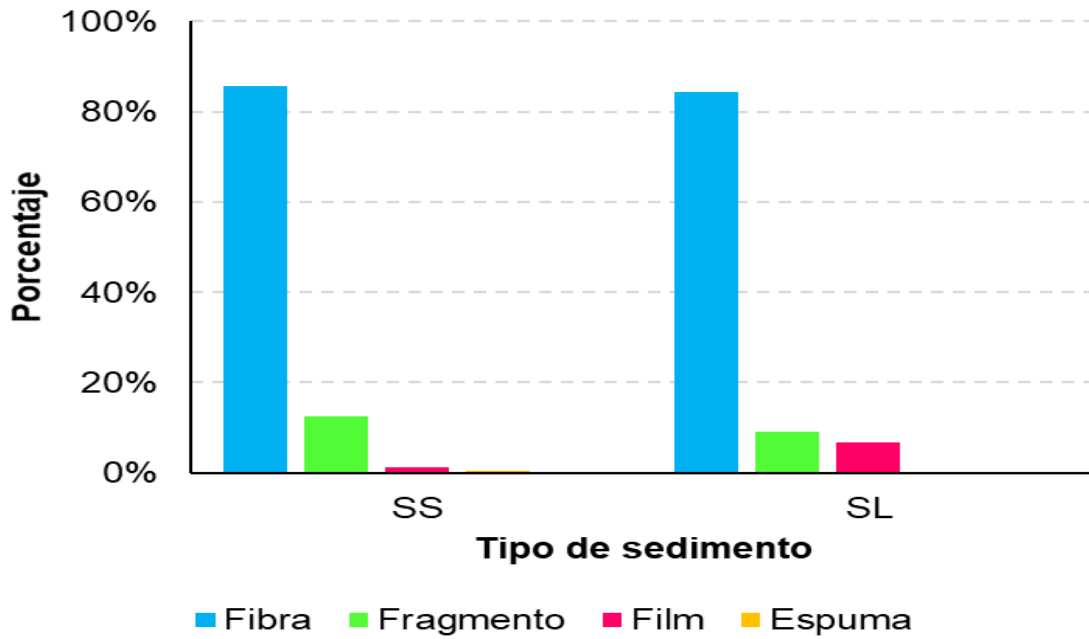
Note: The green color indicates the predominant size range for each site. Source: Prepared by the authors (2025).

Shape

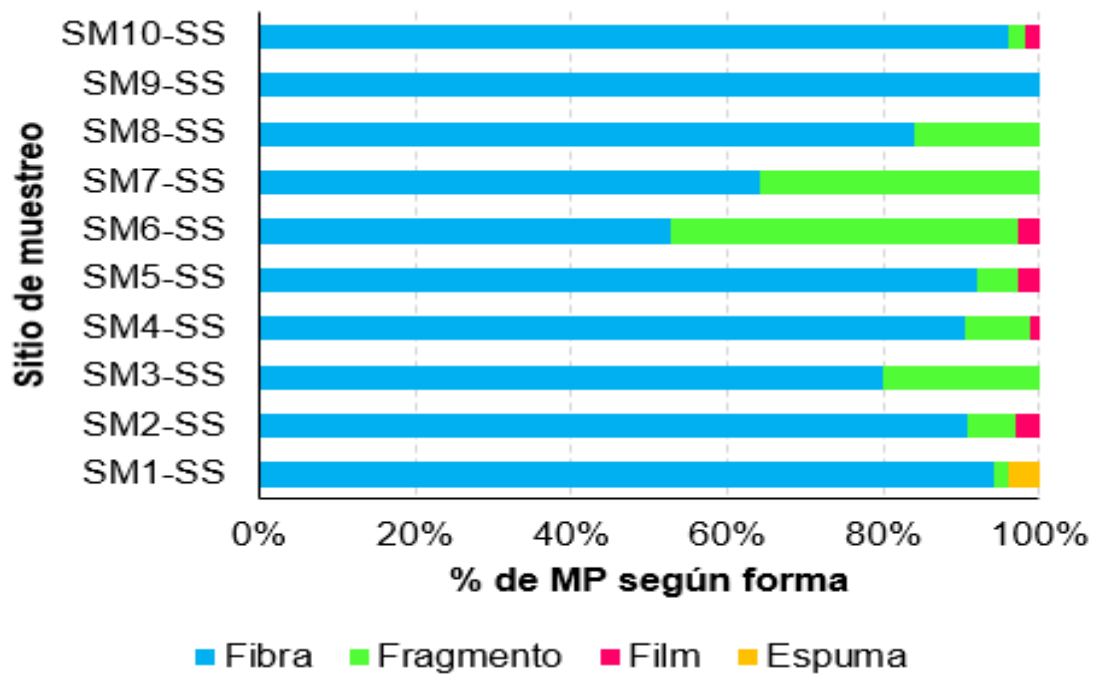
Figure 4A shows that fiber is the predominant shape in SS (85.64%) and in SL (84.29%). At all SS sites, fiber was predominant, with values exceeding 50% for each site (Figure 4B), and in SL, fiber values also exceeded 40% (Figure 4C). In SL in the Negro, Amazon, and Solimões rivers, Brazil (Gerolin et al. 2020), in SL downstream of the Krukut River, Indonesia (Azizi et al. 2022), in SL of the Vaal River, South Africa (Ramaremsa et al. 2022), and in the rivers of the Tibetan Plateau (Jiang et al. 2019), fibers were the predominant type. However, this differs from Canchari & Iannacone (2024), where fragments were predominant in SS in the Ishoj and Uyrú Rume streams in Peru. Fragments were the predominant form in the SS of the Zayandeh-Rud River, Iran (Rami et al. 2023), in the Rímac River, Peru (89.1%) (Huanaco & Gamboa 2023), in the Jequetepeque River, Peru (77.8%) (Manrique 2019), and in the Antuã River, Portugal (Rodrigues et al. 2018). Finally, in the Atoyac River basin, Mexico, film was the dominant form (Shruti et al. 2019).

The fiber-type MP in SS and SL in the present study could be ingested by aquatic biota (Jiang et al. 2019; Schessl et al. 2019), likely originating from the wear and tear of synthetic textiles and laundry waste from synthetic clothing, as well as the degradation of larger plastics (Azizi et al. 2022).

(a)



(b)



(c)

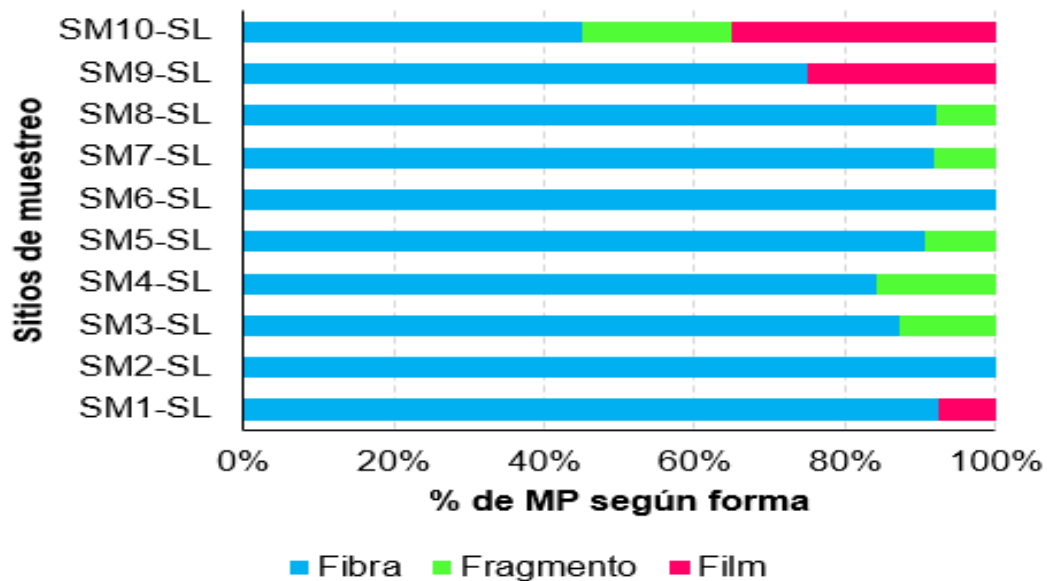


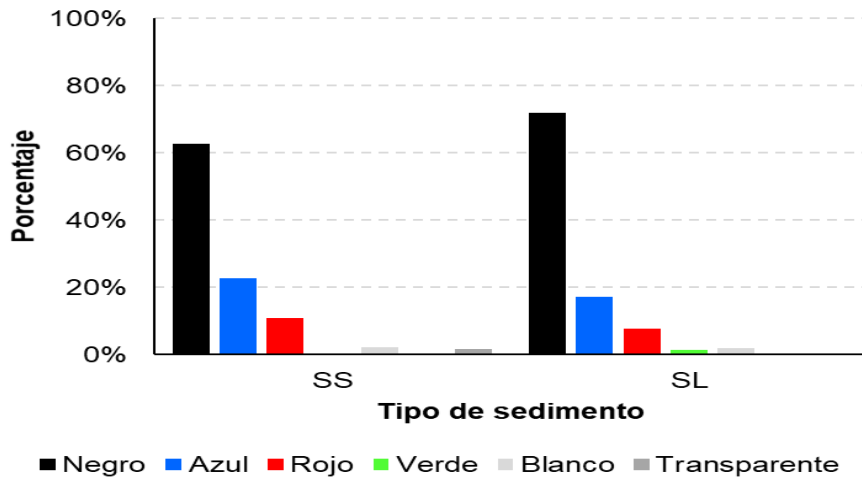
Figure 4. Microplastic shape according to ; percentage of MP in the middle and upper basin by sediment type (a), percentage of MP in surface sediment by site (b), and percentage of MP in bed sediment by site (c) in the Lurín River, Lima, Peru. Source: Prepared by the authors (2025).

Color

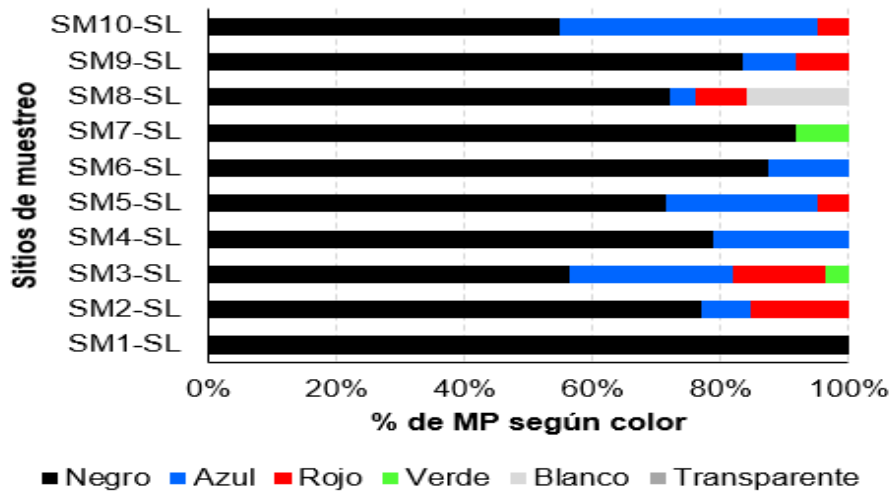
In Figure 5A, black is the predominant color in SS (62.7%) and SL (71.9%) among the evaluated MP. Similarly, in SS and SL by sampling site, black is dominant at 40% and 50%, respectively (Figures 5B and 5C). Our results differ from those of other studies in which transparent was the predominant color in SS in the Ishoj and Uyrú Rume streams, Peru (Canchari & Iannacone 2024), in SS in the rivers of the Tibet Plateau, China (Jiang et al. 2019), and in the Vaal River, South Africa (Ramaremsa et al. 2022). White was the dominant color in SS in the Rímac River, Peru (75%) (Huanaco & Gamboa 2023), in the Atoyac River basin, Mexico (Shruti et al. 2019), and in SL in the Amazon, Solimões, and Negro rivers, Brazil (Gerolin et al. 2020). In these latter studies, black MP was found despite not being the most common.

The color of MP is significant in SS and SL because benthic aquatic biota mistake it for prey and ingest colored MP that resembles their prey, along with the toxins contained in colorants (Roch et al. 2020; Onoja et al. 2022). Many black MP originate from the degradation of plastics used in the casings of household appliances, electronic equipment, and single-use packaging, and often contain brominated flame retardants, which are added to electronic products to prevent fires (Kumar et al. 2025).

(a)



(b)



(c)

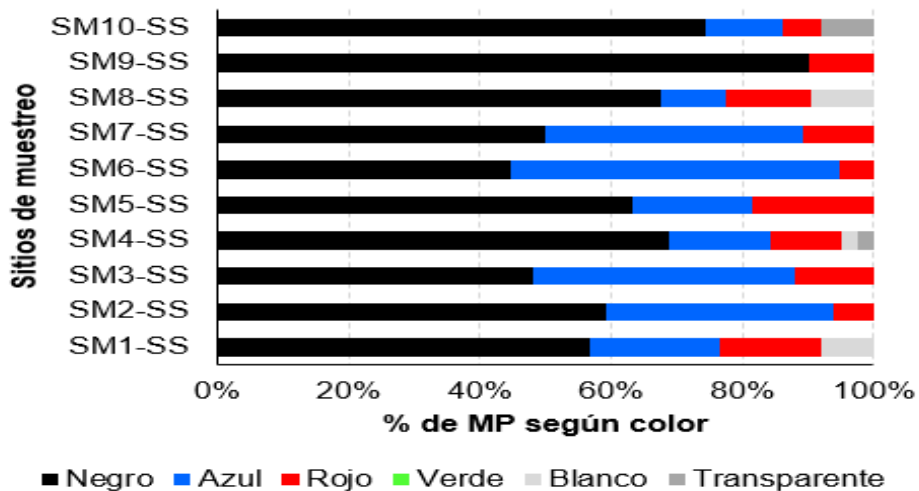


Figure 5. Microplastic color according to: total percentage of MP in the middle and upper basin by sediment type (A), percentage of MP in surface sediment by site (B), and percentage of MP in bed sediment by site (C) in the Lurín River, Lima, Peru. Source: Prepared by the authors (2025).



Figure 6 shows various forms of MP found in this study. Figure 6 (e, i, j, and k) shows evidence of cracks, fragmentation, and erosion on the surfaces, which will give rise to new, smaller MP (Saad et al. 2024). This is because MP are further reducing in size in the environment (Barnes et al. 2009).

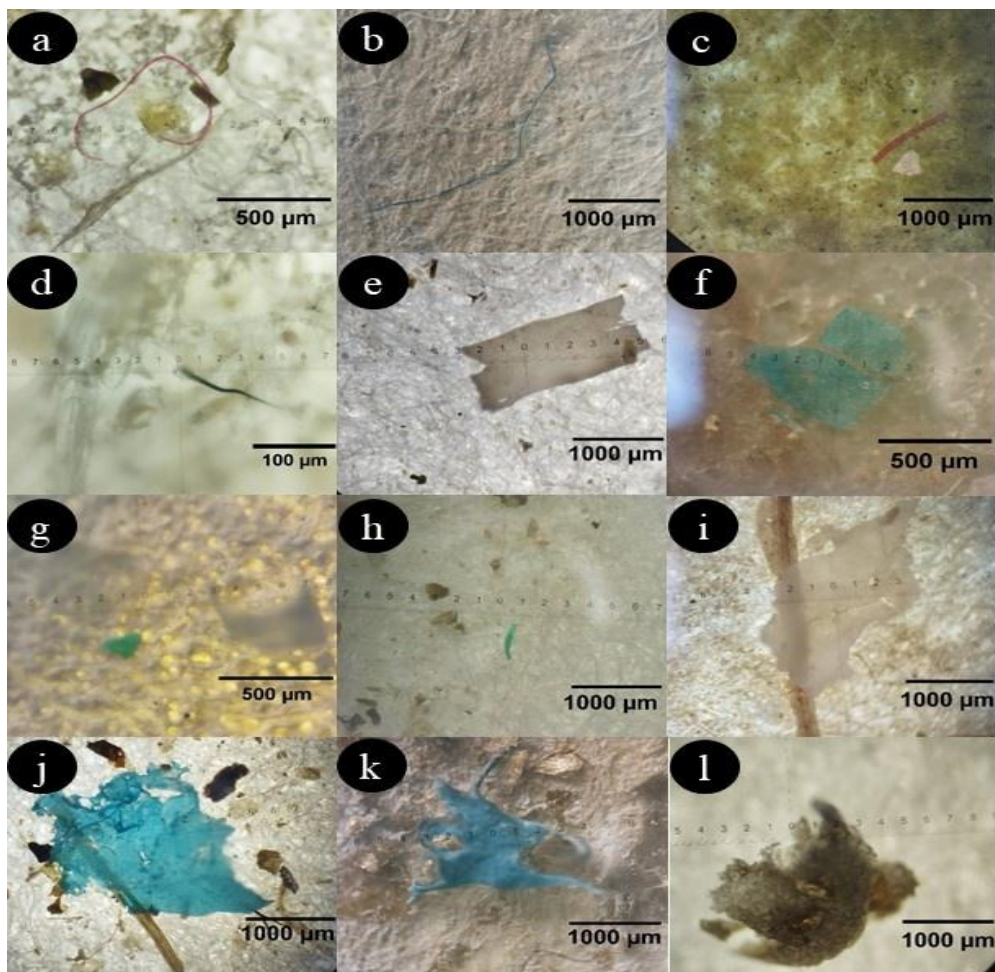


Figure 6. Forms of microplastics: fiber (a, b, c, and d); fragment (e, f, g, h, i); film (j, y, k); and foam (l) found in sediments of the Lurín River, Peru. Source: Prepared by the authors (2025).

This research indicates the presence of putative microplastics, as no chemical identification tests have been conducted to determine the likely types of polymers. Therefore, the data should be interpreted with caution, given the scope of this study. The use of plastics will increase in the future; consequently, the management of solid and plastic waste polluting the Lurín River basin must be improved to prevent macroplastic waste from giving rise to MP (Evode et al. 2021).

Conclusions

This study demonstrated MP contamination of sediments at all sampling sites in surface sediment (SS) and bed sediment (BS) in the middle and upper Lurín River basin, Lima, Peru. The abundance of MP between the two zones (middle and upper basin sites) ranged from 222.22 to 922.22 items/kg of dry sediment for SS and from 88.89 to 611.11 items/kg of dry sediment for SL. The most abundant MP were in the size range of 20 μm –1 mm, fiber-shaped, and black in color. Preventing the leakage of plastics and microplastics into the tributaries and the Lurín River itself is of vital importance for the protection of the environment in the basin. This study serves as a baseline for continued assessment of MP and is intended to



assist authorities in improving solid waste management to prevent the contamination of the Lurín River by plastic waste.

Acknowledgments

We thank the mayors of the districts of San Damián, Lahuaytambo, and Antioquia for authorizing the study. We also thank the Laboratory for Research in Ecology and Animal Biodiversity (LEBA) at the Federico Villarreal National University in Lima, Peru, for providing facilities to carry out the laboratory work.

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