

## Validación de la granulometría de sedimentos como factor clave en la acumulación de microplásticos: análisis comparativo entre los ríos Tena y Pano, Amazonía ecuatoriana

*Validation of sediment granulometry as a key factor in microplastic accumulation: comparative analysis between the Tena and Pano rivers, ecuadorian Amazon*

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### Resumen

Las abundancias de microplásticos (MPs) suelen emplearse como indicadores de contaminación; sin embargo, omitir los procesos sedimentarios puede sesgar su estimación. Este estudio examina la relación entre la granulometría de sedimentos y la acumulación de MPs en dos ríos de la Amazonía ecuatoriana. Se seleccionaron seis zonas en el río Tena y doce en el río Pano utilizando la clasificación de pendientes de Van Zuidam ( $<8^\circ$ ). Tras una única lluvia intensa, se recolectaron 30 muestras de sedimento en el Tena y 60 en el Pano. Los MPs se cuantificaron a partir de 2,5 g de sedimento por muestra, mientras que la granulometría se determinó tamizando 100 g en siete fracciones ( $>2$  mm a  $<63$   $\mu$ m). En total, se registraron 564 MPs en el Tena y 567 en el Pano. Se encontró una correlación positiva significativa entre los MPs y el contenido de limos en ambos ríos (Tena:  $r = 0,46$ ,  $p = 0,009$ ; Pano:  $r = 0,40$ ,  $p = 0,00244$ ). Los resultados demuestran que la granulometría influye fuertemente en la acumulación de MPs y debe reportarse para evitar estimaciones sesgadas.

Palabras clave: Abundancia; Amazonía del Ecuador; Eventos de precipitaciones intensas; Contenido sedimentario; Sistemas de ríos.

## Abstract

Microplastic (MPs) abundances are often used as pollution indicators, yet neglecting sedimentary processes may bias their estimation. This study examines the relationship between sediment granulometry and MPs accumulation in two rivers of the Ecuadorian Amazon. Six zones were selected in the Tena River and twelve in the Pano River using the Van Zuidam slope classification ( $<8^\circ$ ). After a single strong rainfall, 30 sediment samples were collected in the Tena and 60 in the Pano. MPs were quantified from 2.5 g of sediment per sample, while granulometry was determined by sieving 100 g into seven fractions ( $>2$  mm to  $<63$   $\mu$ m). In total, 564 MPs were recorded in the Tena and 567 in the Pano river. A significant positive correlation was found between MPs and muds content in both rivers (Tena:  $r = 0.46$ ,  $p = 0.009$ ; Pano:  $r = 0.40$ ,  $p = 0.00244$ ). Results demonstrate that granulometry strongly influences MPs accumulation and must be reported to avoid biased estimates.

Keywords: Abundance; Ecuadorian Amazon; Heavy rainfall events; Sediment content; River systems.

## Introducción

Microplastic pollution (MPs,  $<5$  mm) is one of the main problems in aquatic ecosystems due to its persistence, mobility, and potential impacts on biota (Andrady, 2011; Cole et al., 2011; Thompson et al., 2004). Its transport and fate depend on anthropogenic pressure, hydrodynamic and sedimentary processes that control its retention (Waldschläger & Schüttrumpf, 2019).

Recent research shows that MPs tend to accumulate in low-energy environments and in fine fractions, highlighting the importance of particle size in their retention patterns (Gerolin et al., 2020). Furthermore, it has been suggested that normalizing data by grain size improves comparability between river studies (Enders et al., 2019).

However, gaps remain regarding how sedimentation processes influence MPs accumulation, with flow dynamics and decantation being key (Enders et al., 2019; Waldschläger & Schüttrumpf, 2019). This aspect is particularly relevant in the Amazon, where seasonality and the input of fine sediments influence contaminant mobility.

Within this framework, this study evaluates the relationship between particle size distribution

and MPs abundance in sediments from the Tena and Pano rivers.

## Metodología

### Study area

The study was conducted in two river systems, the Tena and the Pano River, both located in the Napo province of the Ecuadorean Amazon. These rivers are characterized by high annual rainfall and flow patterns influenced by intense precipitation events.

### Sample collection and preparation

Six zones were selected in the Tena and twelve in the Pano River, choosing areas with slopes  $<8^\circ$  following Van Zuidam criteria (1986) associated with low energy and potential accumulation of fine sediments and MPs. Thirty samples were obtained from the Tena basin and 60 from the Pano basin immediately after a heavy rainfall event. Surface sediments (0–5 cm) were collected with stainless steel spatulas and stored in pre-washed bags. In the laboratory, the samples were dried at  $60^\circ\text{C}$  for three days (100–500 g), and controls were maintained to rule out contamination. In the laboratory, the sediment samples were placed in aluminum containers and oven-dried at  $60^\circ\text{C}$  for three days. After drying, the samples weighed between 100 and 800 g. They were then homogenized, quartered, and divided into two fractions: 100 g for particle size analysis and 2.5 g for MPs quantification. To assess possible contamination during drying and weighing, a control (clean Petri dish) was kept open in the work area.

### Granulometric analysis

To determine the textural composition of the sediment, 100 g of each sample was analyzed by dry sieving. The material was separated into seven particle size fractions:  $>2$  mm, 1 mm, 500  $\mu\text{m}$ , 250  $\mu\text{m}$ , 125  $\mu\text{m}$ ,  $>63$   $\mu\text{m}$ , and  $<63$   $\mu\text{m}$ . Each fraction was weighed on a precision analytical balance ( $\pm 0.001$  g), obtaining the percentage distribution of grain size per sample.

### Extraction and quantification of MPs

The 2.5 g fraction was subjected to density separation with 2.0 g/ml sodium metatungstate solution, left to stand for 48 hours, and then filtered through 0.45  $\mu\text{m}$  cellulose-nitrate membranes. Digestion with 30%  $\text{H}_2\text{O}_2$  and Fenton's solution for 24 hours was followed by further filtration, rinsing with filtered distilled water, and staining with Rose Bengal (200 mg/L). After drying at  $60^\circ\text{C}$  for 1 hour, the MPs were identified and classified (fibers, fragments, films, pellets) under a stereomicroscope.

## Statistical analysis

The relationship between MPs abundance and sediment particle size distribution was evaluated using Pearson's correlation coefficient, with a significance level of  $p < 0.05$ .

## Resultados y Discusión

### Microplastic abundance

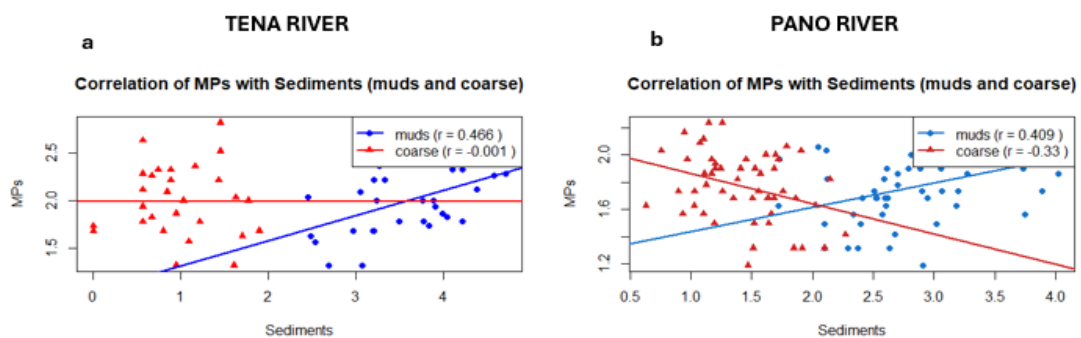
In the Tena River, 564 MPs were recorded in 30 samples (range: 3–63 particles/sample;  $18.8 \pm 13.6$  on average). In the Pano River, 567 MPs were counted in 60 samples (range: 2–25 particles/sample;  $9.5 \pm 5.3$  on average). Although total abundance was similar, the Tena River showed greater variability and local accumulation peaks.

### Sediment granulometry

In both rivers, the fine fraction (muds) ( $<63 \mu\text{m}$ ) predominated, reaching up to 50% of the total weight in most of the samples (Tena M\_24: 50.3%; Pano M-025: 59.6%). Coarse fractions ( $>1 \text{ mm}$ ) were a uncommon ( $<10\%$ ) s, with the exception of two Pano samples where they exceeded 20% (M-033 and M-039)

### Relationship between MPs and granulometry

The correlation analysis showed a significant positive association between MPs abundance and the fine fraction (muds) in both Tena ( $r = 0.46$ ;  $p = 0.009$ ) and Pano ( $r = 0.40$ ;  $p = 0.0024$ ). In contrast, the coarse fractions did not show significant correlations. This supports the hypothesis that fine sediments (muds) function as efficient “traps” for MPs, favored by their higher specific surface area and lower resuspension (Hurley et al., 2018; Waldschläger & Schüttrumpf, 2019).



**Figure 1.** Correlation between microplastics and fine (muds) and coarse (coarse)

sedimentary fractions in the Tena (a) and Pano (b) rivers, Ecuadorian Amazon.

### Ecological implications

The higher retention of MPs in fine fractions suggests that low-energy river zones act as natural sinks for microplastics, limiting their downstream transport but increasing the risk of exposure to benthic organisms (Gerolin et al., 2020). The consistency of results across two independent rivers indicates that sediment grain size is a key predictor that should be considered when estimating MPs accumulation. Ignoring this factor can lead to differences in estimates of up to an order of magnitude (Enders et al., 2019).

## Conclusiones

Particle size distribution is a determining factor in the accumulation of microplastics (MPs) in Amazonian rivers. The fine fraction (muds) (<63  $\mu\text{m}$ ) retains more MPs than coarse fractions, acting as a “natural sink.” The positive correlation between MPs and muds in the Tena ( $r = 0.46$ ) and Pano ( $r = 0.40$ ) rivers confirms that particle size distribution is a reliable predictor of MPs abundance and should be considered in sediment contamination studies. Although total abundance was similar in both rivers, spatial and particle size distribution determined local accumulation points. Future research recommends including temporal dynamics, MPs typology, and other Amazonian rivers to generate robust predictive models of retention and transport.

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