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Short communication

Littering in population centers along the Latin American Pacific coast

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A R T I C L E I N F O

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A B S T R A C T

Urban areas are major sources of anthropogenic litter, as solid waste (SW) generated by daily activities can reach adjacent ecosystems when inadequately managed. This study evaluates whether SW disposal equipment and pedestrian disposal behavior are associated with macrolitter abundance and composition in public spaces across 20 population centers in seven Latin American Pacific countries. SW receptacle abundance ranged from 1 to 14 units 1000 m^{-2}; 3.3% were overflowing, 6.7% full, 60.0% half full, and 30.0% empty, suggesting recent maintenance. A total of 35.9% of the waste items held by the surveyed pedestrians were disposed of improperly, either dropped on the ground or left behind at the location. Among waste types, cigarette butts had the highest proportion of improper disposal (90.5%), followed by plastics (11.5%), and paper (11.1%). All evaluated public spaces were contaminated with macrolitter, with abundances ranging from 0.08 (in Antofagasta, Chile) to 0.61 items m^{-2} (in Santiago, Panamá). Plastics (37.8%) and cigarette butts (33.9%) dominated macrolitter, followed by paper (15.9%), suggesting a link with improperly discarded waste. Macrolitter abundance showed weak negative and positive relationships with SW receptacle abundance and the proportion of improper disposal, respectively, although neither was statistically significant. Our findings highlight cigarette butt littering and the need for improved disposal equipment and management to prevent urban and nearby ecosystem pollution. This study provides an initial assessment of urban littering in the Latin American Pacific region, offering preliminary insights and a multidisciplinary methodology applicable across diverse contexts, serving as a foundation for future research.

1. Introduction

The rapid increase in global waste generation has intensified challenges for waste management systems worldwide (Wilson and Velis, 2015). In many regions, inadequate infrastructure and improper disposal practices contribute to urban littering (Nkwocha and Okeoma, 2009; Darabi et al., 2025). This litter pollution affects urban aesthetics, poses risks to public health, clogs drainage systems, and can contaminate adjacent ecosystems (Srivastava et al., 2015; Nongdren et al., 2024). Indeed, population centers (e.g., cities, towns, and villages) have been identified as major sources of anthropogenic marine litter (AML) in nearby coastal ecosystems (Poeta et al., 2016; Hardesty et al., 2016; Lavergne et al., 2025; Garcés-Ordóñez et al., 2026). AML generated in these population centers may be directly discarded by shore visitors or local shipping activities, or transported to the coast through waterways (Willis et al., 2017; Climo et al., 2022; Hernandez et al., 2026), often resulting in increased AML accumulation after rainfall events (Kasa et al., 2025; Araya-Campano et al., 2026).

A large proportion of litter is produced in public spaces within the population centers themselves (Seco-Pon and Becherucci, 2012; Valiente et al., 2020; Cowger et al., 2022; Nejadsadeghi et al., 2024), influenced by local factors such as the availability and condition of solid

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waste (SW) disposal equipment (e.g., public SW receptacles), the disposal habits of the population, and the efficiency of sanitation services, among others (Sibley and Liu, 2003; Xiong et al., 2022; Darabi et al., 2025). The association between these factors influencing street littering at the scale of everyday public-space use has been mostly studied in developed countries. By contrast, emerging economies have received relatively little research attention (Chaudhary et al., 2021) despite facing significant challenges in waste management and AML pollution (Wilson and Velis, 2015; Honorato-Zimmer et al., 2024). Understanding how these factors interact may help explain littering patterns, relate them to coastal ecosystem pollution, and provide a basis for designing more effective prevention strategies.

Population centers along the Latin American Pacific region, from México to Chile, offer a particularly suitable context to examine the littering issue. Previous studies in the region have shown that a significant proportion of litter found on beaches, especially plastic beverage bottles, originates locally and is commonly observed in urban streets (De Veer et al., 2023; Garcés-Ordóñez et al., 2025). Other studies have also reported deficiencies in SW management systems in coastal cities, including limited equipment coverage, irregular collection services (Muñoz-Cadena et al., 2012; Brooks et al., 2020; Arteaga et al., 2023) and the usage of urban rivers as dumpsites (Garcés-Ordóñez et al., 2023; Honorato-Zimmer et al., 2024). Together, these findings suggest a strong land–sea connection and make these population centers an appropriate setting to evaluate how SW disposal equipment and human behavior influence street littering. Based on this, two general hypotheses can be proposed: (a) if public SW receptacles are scarce or poorly maintained (e.g., full or overflowing), higher litter accumulation should occur on streets, and (b) if disposal habits are inadequate, items discarded by people should constitute a large fraction of the litter present (Muñoz-Cadena et al., 2012; Rossi et al., 2023; Nejadsadeghi et al., 2024).

This exploratory study aims to assess whether the availability and condition of SW receptacles, together with pedestrians' disposal behavior are associated with the macrolitter abundance and composition in public spaces of population centers in Latin American Pacific countries. The study addresses the following questions: (1) What is the quantity and maintenance condition of SW receptacles present in public

Fig. 1. Study area map showing the distribution of sampled populated centers (red pins) across Latin American Pacific countries. See Table S1 for detailed information on sampling sites within each populated center.

spaces? (2) How do people behave when holding SW items that may become litter? (3) What is the abundance and composition of macrolitter on the ground of these public spaces? (4) Is there a relationship between macrolitter contamination, the availability of SW receptacles, and disposal behaviors? This study provides initial insights into factors influencing street littering in Latin American Pacific countries, offers a multidisciplinary methodology applicable across diverse contexts, and may guide future research to better understand this issue in the region.

2. Materials and methods

2.1. Study region and sampling sites

The study area included 20 population centers in seven Latin American countries with Pacific Ocean coastlines: México, Costa Rica, Panamá, Colombia, Ecuador, Perú, and Chile (Fig. 1). Most (75%) of the population centers are located within 10 km of the coast, 20% are between 20 and 35 km from the coast, and only Hermosillo, a city in México, is located 100 km from the coast. The approximate area of these populated centers ranges from ~0.4 to 200 km^2, with population densities between ~800 and 7600 inhabitants km^{-2} (Table S1).

In these centers, we sampled public spaces with high pedestrian traffic, including 12 main squares, four central parks, two municipal markets, one bus terminal, and one public pier. Sampling locations were selected based on site accessibility and access opportunities. As commonly used areas, these spaces concentrate SW disposal equipment, macrolitter accumulation, and allow observation of everyday human behavior under local conditions. Sampling was conducted between July and November 2024 within the framework of the *Científicos de la Basura* program (Litter Scientists) from the Universidad Católica del Norte, Chile. Most (88.9%) of our observations were conducted on weekdays and at different times of the day (9:00 a.m.–6:00 p.m.) across the different public spaces.

2.2. Sampling protocol

A standardized methodological guide was developed and organized into three main sections to conduct the sampling: (1) availability and condition of SW receptacles, (2) human behavior regarding the disposal of SW from consumed products in public spaces, and (3) quantity and composition of macrolitter present on the ground within the sampled public space. The protocol was pilot tested in Coquimbo city (Chile). After discussing methodological aspects, it was refined and subsequently applied in the sampled public spaces.

2.2.1. Solid waste receptacle counts and condition assessment

Within the boundaries of the selected public space in each population center, the number of SW receptacles was recorded, classifying them as bins, dumpsters, and recycling stations. A sketch of the sampling area was produced, explicitly delimiting its borders and recording coordinates using a smartphone. When the site lacked clear boundaries or most receptacles were located along the sidewalk, the area was extended to include those zones, and this was indicated in the sketch. Subsequently, three SW receptacles were randomly selected and for each, the fill level was recorded according to the following categories: (1) empty, (2) half full, (3) full, and (4) overflowing. A SW receptacle was considered overflowing when it was full and at least three litter items were present within a 1 m radius around its perimeter. Additionally, the presence of a bin liner (a plastic bag used in a garbage bin) and the responsible entity (public service or private initiative) were recorded. Finally, a photographic record was taken of each of the three evaluated receptacles.

2.2.2. Observations of littering behavior of pedestrians

In each public space, one to six pedestrians were directly observed while consuming a product within the researcher's visual range (e.g., ice cream, a sandwich, or a cigarette). The number of pedestrians observed varied across sites due to time constraints. After each pedestrian finished consuming the product, their behavior was recorded for up to 2 min to determine the fate of the resulting waste. This time period was based on the method developed by Macaya-Caquilpan (2013), who observed that most consumers in a similar setting discarded the items within 2 min after consumption. Whenever possible, the observer positioned themselves at a location with at least one visible SW receptacle. Only items close to becoming waste were considered (e.g., beverage cans, wrappers, ice cream sticks, or cigarette butts). If the pedestrian left the visual range before finishing consumption or before 2 min had elapsed after the product became waste, the event was not recorded. The approximate age and position of the pedestrian (sitting, standing, or walking) were recorded, as well as their behavior prior to disposal (searching or not for a SW receptacle), the type of SW, and its disposal. The latter was classified into the following categories: (1) placed in a SW receptacle, (2) dropped on the ground, (3) left at the location, or (4) not discarded. Items held by individuals were classified using the same categories applied in the macrolitter surveys (see below). A total of 61 pedestrians were observed across the study area.

2.2.3. Macrolitter survey

The quantity and type of macrolitter (>2.5 cm in size) present on sidewalks adjacent to the selected public space were recorded, including 1 m of roadway (Fig. S1). A measuring tape was used to determine the total width of the transect. Subsequently, a fixed and identifiable element of the sidewalk (e.g., a signpost) was selected and photographed to mark the beginning and end of the transect. A printed survey form was used to record sampling information (date, sampling time, name of the public space, populated center, and country), transect limits (width), and macrolitter categories: cigarette butts, plastics (including all types of plastics except cigarette butts), metals, glass, paper, organic waste, and others. For items classified under the "others" category, the observed material was specified. Litter items were recorded individually while the researcher walked along the sidewalk.

2.3. Statistical analysis

The abundance of SW receptacles (units 1000 m^{-2}) and macrolitter (items m^{-2}) was normalized using the sampled area, which was calculated on Google Earth (with the polygon tool) based on the recorded geographic references. Proportions were estimated for each SW receptacle fill-level category, for the types of macrolitter recorded on the ground and SW held by the observed pedestrians, and for the disposal outcome categories. Associations between macrolitter abundance and SW receptacle abundance, the proportion of items disposed of improperly (dropped on the ground + left at the site), population density (people km^{-2}), and urban area (km^2) were assessed using Spearman's rank correlations (ρ). This non-parametric test was selected due to the small sample size ($n = 19$) and its ability to detect monotonic relationships without assuming normality or homoscedasticity. No macrolitter abundance data were available for David (Panamá); therefore, only 19 population centers were included in the correlation analysis. For each pair of variables, ρ and statistical significance were estimated using asymptotic approximations because of tied values. Analyses were conducted at the population center level, treating each site as an independent unit.

A contingency table was constructed to assess the association between the type of waste held by pedestrians and its disposal (proper vs. improper). Each observation corresponded to one pedestrian recorded during sampling. Waste type was classified into nominal categories (cigarette butts, plastics, paper, organic waste, and others), and disposal outcome was coded as a binary variable (proper disposal = either placed in a bin or kept; improper disposal = either dropped on the ground or left at the site). Absolute frequencies and row proportions were calculated to estimate the probability of improper disposal within each waste category. Given the small sample size (n = 61) and low expected cell counts (<5), Fisher's exact test was used to evaluate independence between variables. The statistical analyses were performed in R using a 0.05 significance level and following methodological guidelines from Dytham (2011) and Bakker (2024).

3. Results

3.1. Solid waste receptacle availability and fill level

The abundance of SW receptacles in the evaluated public spaces ranged from 1 to 14 units 1000 m^{-2}. The lowest abundance was recorded in the main square of Arica city, Chile, whereas the highest was observed at the pier of Juanchaco, a village in Colombia (Fig. 2A). Most SW receptacles were bins and were found in all evaluated public spaces, whereas dumpsters and recycling stations were only observed in four population centers. Regarding SW receptacle fill levels, 3.3% of all recorded units were overflowing, 6.7% were full, 60.0% were half full, and 30.0% were empty. Receptacles classified as full or overflowing were recorded in Ecuador, Colombia and Panamá (Fig. 2B). Most of the SW receptacles (58.3%) did not have a bin liner (Fig. S2). A total of 86.7% of the SW receptacles belonged to public entities, while the remaining percentage corresponded to private initiatives (Fig. S3).

3.2. Pedestrian disposal behavior

Plastic items were the most frequently observed waste type in the hands of pedestrians (40.6%), followed by cigarette butts (32.8%), paper (14.1%), organic waste (3.1%), and other materials such as glass, metal, and processed wood, which together accounted for 9.4% (Fig. 3A). Only 55% of the observed pedestrians searched for a SW receptacle. Most items held by pedestrians (51.56%) were disposed of in a SW receptacle, 31.25% were dropped on the ground, 12.50% were retained during the observation period, and the remaining 4.69% were left at the location. Improper disposal behavior was more frequently observed among pedestrians in Hermosillo (México), Bahía Solano

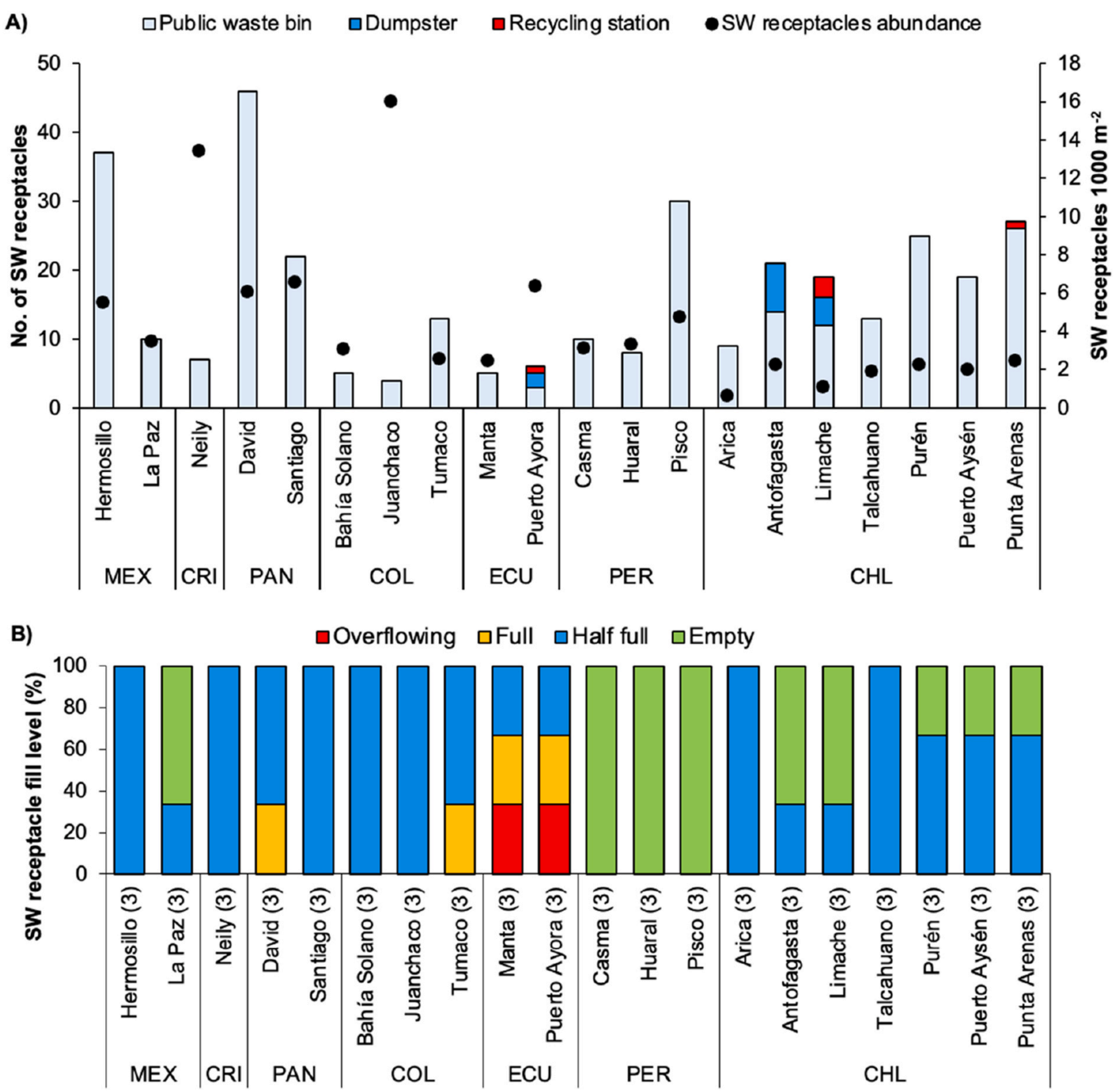

Fig. 2. Abundance of solid waste (SW) receptacles (A) and their fill level (B) in public spaces of populated centers and countries of the Latin American Pacific region. ISO country codes: México (MEX), Costa Rica (CRI), Panamá (PAN), Colombia (COL), Ecuador (ECU), Perú (PER), and Chile (CHL). The numbers in parentheses in panel B correspond to the number of SW receptacles evaluated in each populated center.

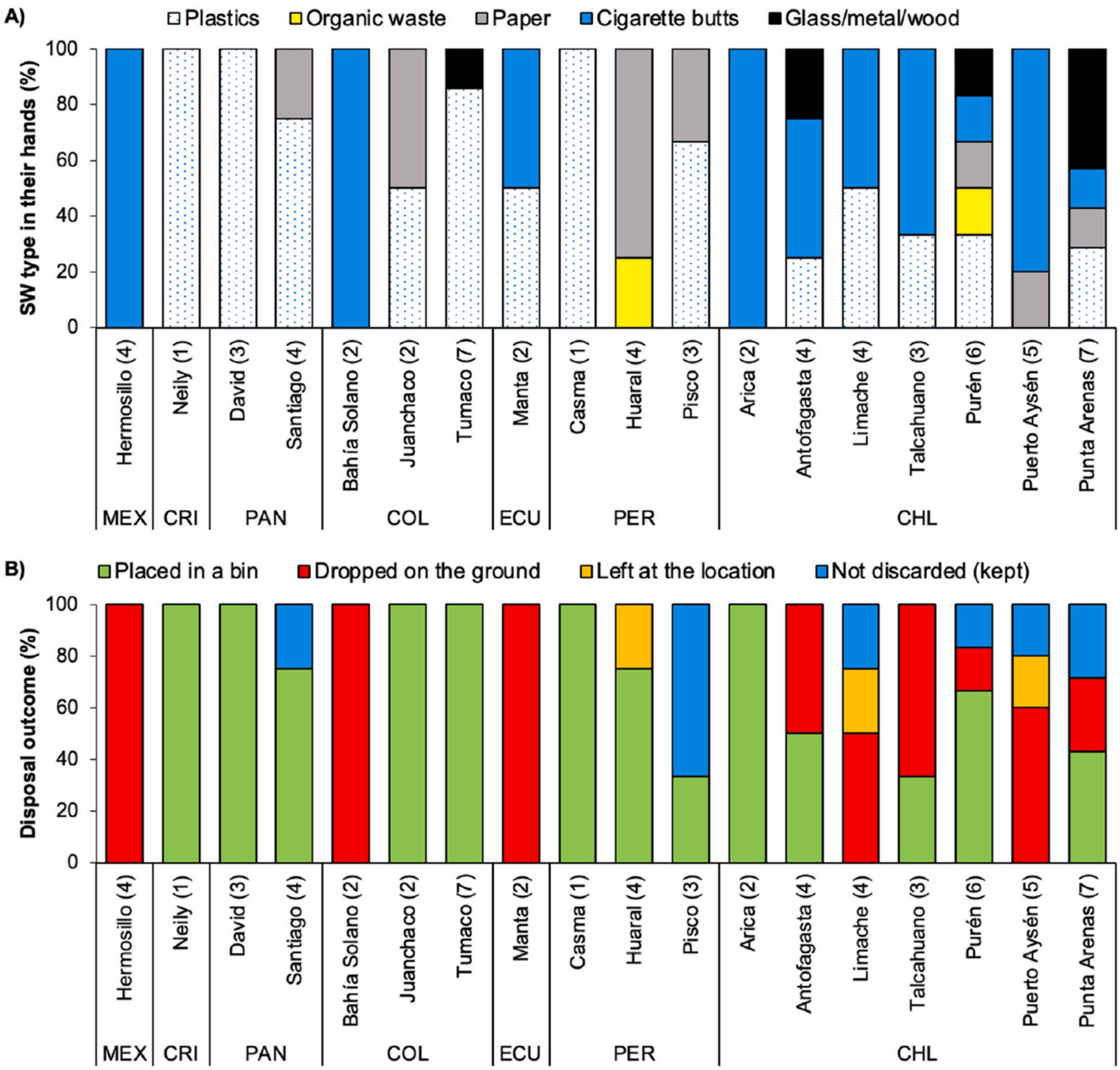

Fig. 3. Proportions (%) of solid waste (SW) type in the hands of observed pedestrians (A) and their disposal outcome (B) in public spaces of population centers and countries of the Latin American Pacific region. ISO country codes: México (MEX), Costa Rica (CRI), Panamá (PAN), Colombia (COL), Ecuador (ECU), Perú (PER), and Chile (CHL). The numbers in parentheses indicate the number of disposal events or waste items observed at each public site within the population centers of the study area.

(Colombia), Manta (Ecuador), and six population centers in Chile (Fig. 3B).

A significant association was found between waste type in hands of observed pedestrians and disposal outcome (Table 1). Cigarette butts showed the highest proportion of improper disposal, with 90.5% of observed items being dropped on the ground. In contrast, plastics and paper waste were predominantly disposed of properly, while no cases of improper disposal were recorded for organic waste or the "other" category (Table 1).

Table 1
Contingency table showing the percentage of proper and improper disposal by solid waste type observed in the hands of the observed 61 pedestrians. A few pedestrians carried more than one type of material (e.g., plastic and glass; plastic and metal), totaling 64 waste items (n). A significant association was detected between waste type and disposal outcome (Fisher's exact test, $p < 0.001$).

Solid waste type in hands of observed people	n	Proper disposal (%)	Improper disposal (%)
Cigarette butts	21	9.5	90.5
Plastics	26	88.5	11.5
Paper	9	88.9	11.1
Organic waste	2	100.0	0.0
Other (metals, glass and processed wood)	6	100.0	0.0

3.3. Macrolitter abundance and composition

A total of 3902 macrolitter items were recorded. Macrolitter abundance ranged from 0.08 to 0.61 items m^{-2}. The highest value was observed in Santiago de Veraguas (Panamá), whereas the lowest was recorded in Antofagasta (Chile) (Fig. 4).

In terms of composition, plastics (which included multiple litter types) represented the largest category, accounting for 37.8% of the total. Cigarette butts, treated as a separate category, were also highly abundant and represented 33.9% of all macrolitter items. Paper was the third most common material, representing 15.9% of the total. Other materials, including metals, glass, organic waste, and miscellaneous

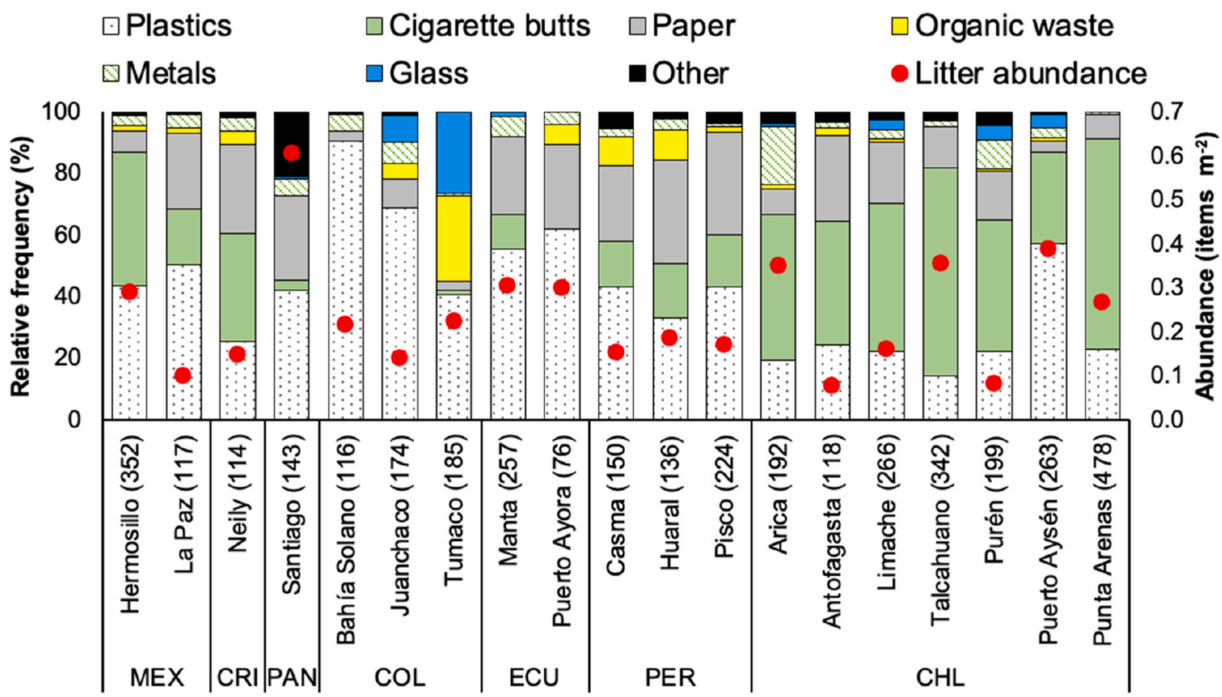

Fig. 4. Macrolitter composition (%) and abundance (items m^{-2}) on public space ground in populated centers and countries of the Latin American Pacific region. ISO country codes: México (MEX), Costa Rica (CRI), Panamá (PAN), Colombia (COL), Ecuador (ECU), Perú (PER), and Chile (CHL). The numbers in parentheses correspond to the number of macrolitter items recorded in each populated center.

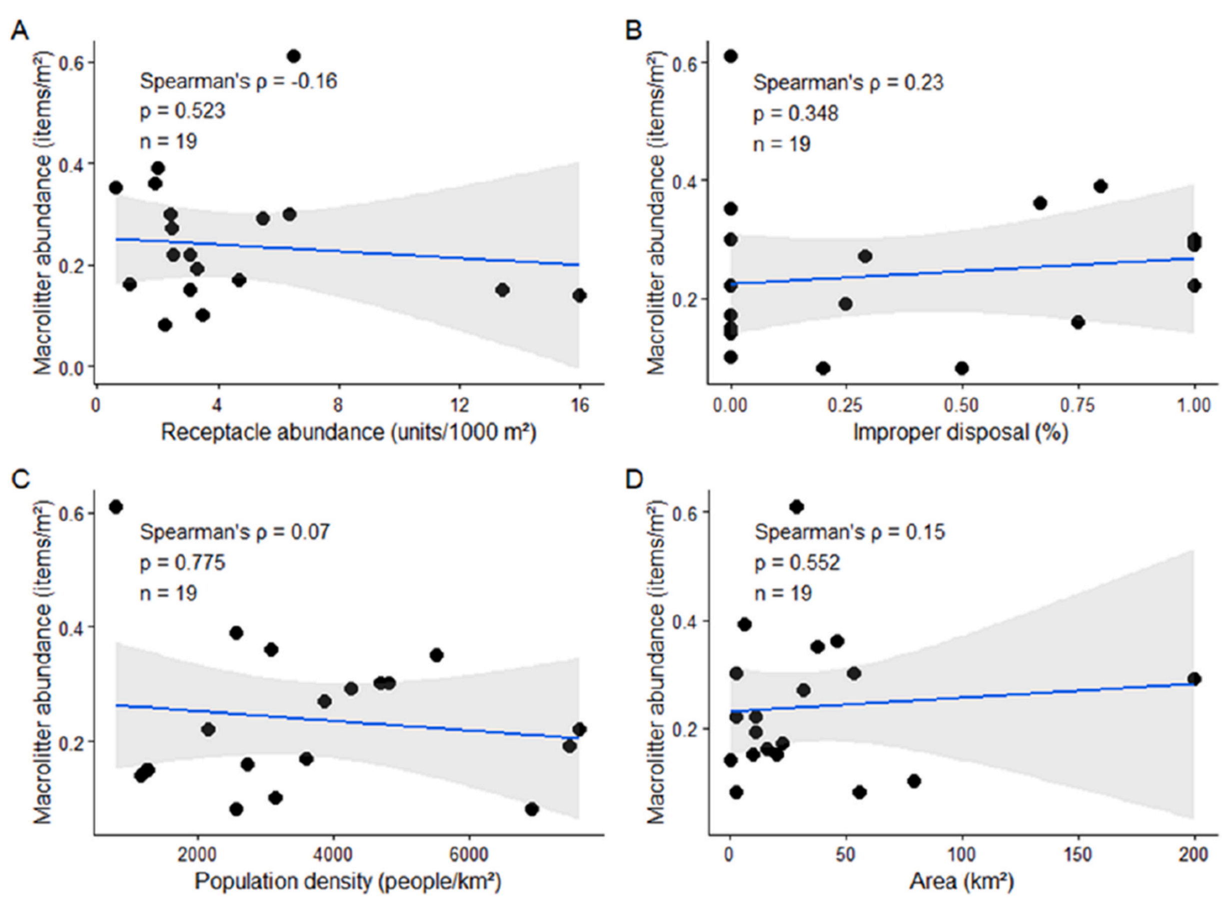

Fig. 5. Spearman correlations between macrolitter abundance and (A) solid waste (SW) receptacle abundance, (B) improper disposal of SW, (C) population density, and (D) urban area across population centers of the Latin American Pacific region. Points represent observed population center-level values (n = 19), solid lines indicate fitted linear trends for visualization, and shaded areas represent 95% confidence intervals.

items, each accounted for between 2.5% and 4.2% of the total (Fig. 4). Weak, non-significant relationships were observed between macrolitter abundance and SW receptacle abundance (negative; Fig. 5A), improper disposal (positive; Fig. 5B), population density (no clear trend; Fig. 5C), and urban area (positive; Fig. 5D).

4. Discussion

4.1. Solid waste receptacles and macrolitter abundance

This study assesses macrolitter across different types of public spaces in populated centers varying in size and population density. Our results indicate a trend consistent with our initial expectation: macrolitter abundance decreased as SW receptacle availability increased. However, this trend was weak and not statistically significant; therefore, the hypothesis was not fully supported by the data. This may reflect the limited sample size and contextual variability among population centers. SW receptacles in public spaces are essential infrastructure for preventing littering and reducing the risk of pollution in adjacent ecosystems, yet their effectiveness also depends on adequate management, accessibility, and the social context in which they operate; poorly maintained or insufficiently distributed receptacles may discourage proper waste disposal and contribute to litter accumulation in urban environments (Muñoz-Cadena et al., 2012; Darabi et al., 2025).

In our study, a high proportion of SW receptacles are recorded as half full or empty, and 41.7% are equipped with internal liners, suggesting that they are being serviced regularly. Most sampled public spaces are main squares and central parks, which typically include benches, sidewalks, and planters, areas reported to be difficult to clean and prone to litter accumulation (Darabi et al., 2025). Small items such as cigarette butts and bottle caps, which were among the most abundant items in our study, are commonly associated with these settings and have been reported as most abundant items in other cities worldwide (Muñoz-Cadena et al., 2012; Seco-Pon and Becherucci, 2012; Becherucci and Seco Pon, 2014; Yousefi-Nasab and Parseh, 2024; Rossi et al., 2023; Pietrelli et al., 2025).

Waste management context is also relevant in Latin America. Coastal cities generate substantial volumes of plastic waste and show high rates of mismanaged waste (30 to 3800 kt year^{-1}; Brooks et al., 2020), with plastic pollution documented both in urban streets and on beaches (De Veer et al., 2022; Garcés-Ordóñez et al., 2025). In smaller coastal villages such as Juanchaco and Bahía Solano (Colombia), community initiatives were responsible for installing and managing SW receptacles. Notably, Juanchaco (Colombia) had the highest abundance of SW receptacles, all of which were equipped with liners. Smaller towns with limited populations may generate less waste overall, whereas larger urban centers can face systemic management limitations. For example, in Chiclayo (Perú), only 47% of urban SW is reported to be collected, with the remainder accumulating in streets, parks, and drainage areas (Arteaga et al., 2023), a situation that could be occurring in several of the coastal cities in the study area. Additionally, few of the evaluated public spaces included recycling stations or dumpsters, which may also influence littering dynamics.

Comparatively, total macrolitter abundance in this study was lower than values reported for Argentina, Italy, and Australia, but similar to ranges observed in Iran and other Latin American cities (Table 2). Cigarette butt abundance in this study was lower than the highest values reported globally, but comparable to those observed in China, the Philippines, Brazil, and some Iranian cities (Table 2), remaining within a low-to-intermediate global range. The observed differences could be due to the timing of the surveys or specific site conditions. Since most of these public spaces receive high numbers of visitors, they are cleaned daily; therefore, the time of day when surveys are conducted is critical. For example, Nejadsadeghi et al. (2024) and Yousefi-Nasab and Parseh (2024) conducted their sampling 2 h before sunset, whereas Becherucci and Seco-Pon (2014) sampled in the early morning, before cleaning and after extensive nocturnal activities, possibly resulting in the higher SW densities observed.

Table 2
Abundance of total litter or cigarette butts in urban spaces from around the world. The results of this study are highlighted in bold. (–) no information available. The comparison should be interpreted as a broad overview of observed patterns, as the studies were conducted using different sampling methods.

Location	Total litter (items m^{-2})	Cigarette butts (items m^{-2})	Reference
Mar del Plata (Argentina)	9.5 – 14.3	-	Seco-Pon and Becherucci (2012); Becherucci and Seco-Pon (2014)
108 cities (Italy)	3.82	-	Pietrelli et al. (2025)
Large cities (Australia)	>2.0	-	Schuyler et al. (2022)
Ardakhan (Iran)	0.23 – 0.95	-	Hezarvand et al. (2025)
Behbahan and Tehran (Iran)	0.01 – 0.74	-	Nejadsadeghi et al. (2024); Yousefi-Nasab and Parseh (2024)
Six large cities (Iran)	<0.01 – 0.65	-	Jaafarzadeh et al. (2024)
Latin American cities	0.01 – 0.50	-	De Veer et al. (2022)
Latin American cities	**0.08–0.61**	**0.00–0.24**	**This study**
Niterói and Santos (Brazil)	-	0.08 – 0.25	Ribeiro et al. (2022)
Laguna (Brazil)	-	0.50	Dantas et al. (2025)
Guarujá (Brazil)	-	0.01 – 0.68	Ribeiro et al. (2026)
Coastal and inland cities (China)	-	0.03 – 0.10	Yang et al. (2024)
Dalian (China)	-	0.09 – 0.11	Yang et al. (2023)
Berlin (Germany)	-	0.29 – 5.2	Green et al. (2014)
Aizawl (India)	-	0.15 – 0.63	Nongdren et al. (2024)
Jiroft (Iran)	-	0.01 – 0.61	Salehi et al. (2022)
Behbahan (Iran)	-	0.03 – 0.61	Darabi et al. (2023); Feizi et al. (2025)
Mashhad (Iran)	-	0.19 – 2.33	Babaei et al. (2025)
Amol and Sari (Iran)	-	0.05 – 0.67	Yousefi-Nasab et al. (2022)
Tubod, Iligan City (Philippines)	-	0.08	Araña et al. (2026)
Hanoi (Vietnam)	-	0.01 – 1.16	Hoang et al. (2024)

4.2. Pedestrian disposal behavior and macrolitter pollution

The mere presence and maintenance of SW receptacles do not fully explain patterns of macrolitter accumulation; pedestrian disposal behavior also plays a critical role (Nejadsadeghi et al., 2024; Darabi et al., 2025). In this study, 35.9% of the waste items observed in pedestrians' hands were either dropped on the ground or left at the location, confirming the occurrence of improper disposal behavior in the evaluated public spaces. Cigarette butts, paper, and plastics are the waste types most often disposed of improperly by pedestrians, and they are also the main components of macrolitter in public spaces. Therefore, the hypothesis that inadequate disposal habits contribute substantially to the accumulation of discarded items on the ground is supported.

Paper items frequently discarded consist mainly of receipts and tickets. These items are lightweight and easily transported by wind, which may partially explain their lower abundance in ground surveys compared to plastics. Although plastics showed a relatively low rate of improper disposal during observations, they remain widely used in consumer products (Ncube et al., 2021). Some plastic items, such as beverage bottles, may be removed by informal recyclers due to their economic value, similar to glass bottles and metal cans (Economist Intelligence Unit, 2017; Botello-Álvarez et al., 2018). In contrast, other plastics, such as expanded polystyrene items, disposable face masks, loose bottle caps, and small fragments are rarely collected for recycling and tend to persist in the street and natural environment (De-la-Torre et al., 2021; Thiel et al., 2021; De Veer et al., 2023; Rossi et al., 2023; Garcés-Ordóñez et al., 2025).

The high frequency of cigarette butts on streets reflects both high consumption levels and common disposal practices, as smokers often extinguish cigarettes on the ground and leave them there (Valiente et al., 2020; Conradi and Sánchez-Moyano, 2022; Yang et al., 2024). The proportion of improperly discarded cigarette butts is higher or similar to those reported from public places in the USA (65% - Schultz et al., 2013) and in New Zealand (77% - Patel et al., 2013; 99% - Sibley and Liu, 2003), underscoring the urgency of the problem. Public parks, squares, and transport areas are frequently reported as hotspots for cigarette-related litter (Valiente et al., 2020; Pietrelli et al., 2025; Ribeiro et al., 2026). Moreover, previous studies indicate that urban littering behaviors vary depending on nearby service establishments and local activities. For example, paper waste may be more common near ATMs, cigarette-related litter near bars and supermarkets, and distinct material types may predominate during festivals or other cultural events (Valiente et al., 2020; Darabi et al., 2025). Macrolitter abundances therefore represents the outcome of cumulative processes integrating multiple disposal events over time (Conradi and Sánchez-Moyano, 2022; Darabi et al., 2025) that are additionally affected by the cleaning schedules in each location.

Several limitations should be acknowledged. Observations were conducted at different times across population centers, thus not capturing macrolitter abundance and pedestrian variation at specific times of day, which likely varies among cities and regions, as well as with work schedules and festivities (Darabi et al., 2025). In addition, the behavioral sample was relatively small (61 individuals), and the assessment of SW receptacle maintenance was based on a limited number of observations per site. These constraints restricted the application of more complex statistical models and limited city-level compositional comparisons. Nevertheless, this exploratory assessment provides an important regional baseline for understanding urban litter dynamics in the Latin American Pacific and supports the need for broader temporal and spatial investigations integrating more dimensions. Future studies at specific locations should include surveys conducted across multiple sites and over longer time periods, incorporating variations in visitor presence and activity. Such approaches would support the development of site-specific intervention strategies to reduce littering and maintain cleaner public spaces.

5. Outlooks and recommendations

This study represents an initial effort in the Latin American Pacific region to examine the relationships among SW receptacle equipment, pedestrian disposal behavior, and macrolitter composition in public spaces across different population centers. Our results indicate that public spaces show accumulations of macrolitter, dominated by cigarette butts, other plastic items, and paper. These patterns partly reflect improper pedestrian waste disposal but may also be influenced by multiple and cumulative processes, including the availability of SW equipment, individual disposal decisions in specific local contexts, and likely factors such as time of day, day of the week, weather, visitor frequency, and surrounding commercial activities (Schuyler et al., 2022; Darabi et al., 2025). Future research should increase the sample size and expand the spatial and temporal scale of observations to improve statistical power and better capture contextual variability. In addition, integrating socioeconomic variables, the efficiency of SW management systems, and behavioral factors are recommended to more comprehensively understand the drivers of litter accumulation in urban areas across the region. Identifying the producer companies would be helpful in recruiting them to the efforts of reducing littering of these products in urban and natural environments (e.g. Cowger et al., 2022).

Cigarette butts, besides reflecting tobacco consumption and its associated public health risks, represent an important source of urban and natural environmental pollution (Champagne et al., 2010; Valiente et al., 2020). They contain toxic chemical compounds that can leach into the environment and affect soil, water quality, and species (Dobaradaran et al., 2021). Prevention strategies aimed at addressing this problem should prioritize reducing tobacco consumption and promoting smoking cessation (Teran, 2025; Bolaños Casarín et al., 2026). Complementary actions include environmental education and improved urban solid waste management, such as installing and maintaining receptacles, with adaptations for cigarette butts, in visible and accessible locations in high-traffic public areas. This could reduce improper disposal and limit the dispersion of these wastes in urban environments and surrounding ecosystems.

CRediT authorship contribution statement

Ostin Garcés-Ordóñez: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. **Mauricio Ergas:** Conceptualization, Data curation, Investigation, Methodology, Validation, Writing – review & editing. **Daniela Honorato-Zimmer:** Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. **Nelson Vásquez:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Writing – review & editing. **Josefa Araya-Campano:** Conceptualization, Investigation, Methodology, Validation, Writing – review & editing. **Jostein Baeza-Álvarez:** Conceptualization, Funding acquisition, Methodology, Validation, Writing – review & editing. **Martin Thiel:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2026.130258.

Data availability

All data are available online.

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