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Microplastic occurrence in water and sediments at Bacalar Lake, Quintana Roo, México

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ABSTRACT

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Microplastics represents a global concern, but information available on tropical lakes is limited. Microplastic occurrence in water and sediments was assessed at Bacalar Lake. Plankton tows were conducted in July, October 2022, and March 2023 in four sites, while sediments were collected in 15 sites. In water, dominant microplastic were fibers, fragments, films, and beads/pellets, with similar abundance in July and October, and higher in March. Higher abundance occurred on S24 in October and March with 1.56 and 0.94 items/1000 m^3. In sediments only fibers were found, (667 particles/kg) with transparent fibers (303 items) as the most abundant. The abundance of microplastics was lower (0.04 particles/kg), except for site S30 (0.88 particles/kg) in July 2022. Eighteen plastic polymers were identified in water and sediments, cellophane and copolymers Polystyrene: vinylidene chloride and polyethylene propylene: diene had percentages of 40%, 38% and 12%, respectively. In the water column, 85% of the microplastics corresponded to fibers composed of cellophane, Polystyrene: vinylidene chloride and polyethylene propylene: diene; and Alkyd resin, Polyvinylidene fluoride, and Polyamide 6+Polyamide 6.6 in fragments. In sediments, fibers represented 87%, and PS polymers dominated: Polystyrene: vinylidene chloride and cellophane, as well as polyethylene propylene: diene. The greatest abundance of microplastics was found in sites near to Bacalar Town and urban centers where tourism is most intensified. In general, the microplastic concentration in Bacalar Lake is low.

KEY WORDS: Freshwater, karst, sediments, urban tourism development.

RESUMEN

Presencia de microplásticos en agua y sedimentos en la Laguna de Bacalar, Quintana Roo, México.

Los microplásticos representan una preocupación mundial, pero la información disponible sobre lagos tropicales es limitada. Se evaluó la presencia de microplásticos en agua y sedimentos en la Laguna de Bacalar. Se realizaron arrastres de plancton en julio, octubre de 2022 y marzo de 2023 en cuatro sitios, además se recolectaron sedimentos en 15 sitios. En el agua, los microplásticos predominantes fueron fibras, fragmentos, películas y esferas/gránulos, con una abundancia similar en julio y octubre, y mayor en marzo. La mayor abundancia se presentó en S24 en octubre y marzo, con 1.56 y 0.94 elementos/1000 m^3. En los sedimentos solo se encontraron fibras (667 partículas/kg), siendo las fibras transparentes (303 elementos) las más abundantes.

La abundancia de microplásticos fue menor (0.04 partículas/kg), excepto en el sitio S30 (0.88 partículas/kg) en julio de 2022. Se identificaron dieciocho polímeros plásticos en agua y sedimentos: el celofán y los copolímeros poliestireno: cloruro de vinilideno y poli (etileno propileno: dieno) presentaron porcentajes del 40%, 38% y 12%, respectivamente. En la columna de agua, el 85% de los microplásticos correspondió a fibras compuestas de celofán, cloruro de vinilideno y poli (etileno propileno: dieno) (copolímero PE: PP); y fragmentos de resina de alquilo, Polyvinilideno y Poliestireno A6+Poliestireno A6.6. En sedimentos, las fibras representaron el 87%, predominando los polímeros Poliestireno: Poliestireno vinilideno y celofán, así como Polietileno propileno dieno. La mayor abundancia de microplásticos se encontró en sitios cercanos al pueblo de Bacalar y a los centros urbanos, donde el turismo es más intenso. En general, la concentración de microplásticos en la laguna de Bacalar es baja.

PALABRAS CLAVE: *agua dulce, kárstico, sedimentos, desarrollo turístico urbano.*

INTRODUCTION

Plastic pollution is considered one of the greatest environmental threats of the Anthropocene, which constitutes a concern at scientific, social, and governmental levels (Brander et al., 2020). Microplastics (MP) are pieces of polymers less than 5 mm (Yang et al., 2021; Ehlers et al., 2022) that can be found in different forms, such as microbeads, microfilms, microfibers, and micro fragments their origin can be primary or secondary, according with product of microplastic degradation. Plastic is absorbent and engages hydrophobic chemicals (pesticides, steroids, Bisphenol A [BPA]) from the surrounding water while floating or depositing. Microplastics effects on freshwater aquatic systems are unfortunately poorly understood and valued when compared with marine evaluations (Pelamatti et al., 2019; Cera et al., 2020; Cruz-Salas et al., 2022; Ehlers et al., 2022; Akinhanmi et al., 2023; Jolaosho et al., 2025).

In Mexico, the assessment of plastic debris has been studied in marine environments (Piñon-Colin et al., 2018; Ramírez-Álvarez et al., 2020; Moreno-Rodríguez et al., 2024). In Quintana Roo, Álvarez-Zeferino et al. (2020) evaluated MP in Holbox and Playa del Carmen, and recently Cruz-Salas et al. (2022) evaluated the MP on the sandy beaches of Holbox, where polyethylene and polypropylene were the most abundant MP at both sites sampled. There is only one publication dealing with microplastic content in freshwater sediments in central Mexico (Shruti et al., 2019). In southern Quintana Roo there is only one study related to the distribution and abundance of MP on sandy beaches at Chetumal Bay (García, 2016). However, information on the content of MP in epicontinental aquatic systems, such as Bacalar Lake, has not been published yet, even when a fast touristic and urban development occurred ten years ago with 200 thousand visitors per year. The aim of this study was to evaluate the distribution and abundance of MP in the water and sediments of Bacalar Lake throughout different climatic seasons. We will test the hypothesis that the distribution and abundance of MP is correlated with land use: agricultural, urban, and touristic.

MATERIALS AND METHODS

Study area

The Bacalar Lake is in southern Quintana Roo (19° 00″ 18° 30″N, 88° 15″ 88° 30″W). The Lake is 40 km long and 1-2 km wide, in a NE-SW orientation (Comisión Nacional del Agua, 2015). The lake depth is 8.85 m average, with a maximum depth at the northern part (26 m) and some sink holes in the south, with depths of 38 m, 48.5 m, and 63.6 m. There are no surface rivers in Bacalar, and hydrology depends on subterranean water (Carrillo et al., 2024). In fact, the Bacalar Lake is a downfaulted basin, dated on Late Cretaceous and Pliocene and aligned with the southern Caribbean coast (Isphording, 1975). The average annual rainfall in the region ranges 100-1500 mm/year, with mean temperatures during winter and summer of 28.0°C and 29.1 °C, respectively. Agricultural activities are taking place in the northern and central parts of the lake, with a significant impact from the Mennonite community, which practices large-scale agriculture with intensive use of agrochemicals in the central area, while in the south there is located the city of Bacalar and most of the tourist infrastructure, such as hotels and boats.

MP in the water column and sediments

The Bacalar Lake has been subject to constant monitoring since 2015. The information on water quality and concentration of pollutants has allowed three zones to be selected: North section with greater agricultural activity, Center section where Mennonite agricultural area and the city is located with a predominance urban use, and South section with more tourist activities, like hotels and traveling boats (Tarjeta de Reporte Bacalar, 2021).

Four sites (S2, S22, S24, and S30) were selected according to the Bacalar Report card (Tarjeta de Reporte Bacalar, 2021) (Fig. 1). MP were collected from the water column in duplicate, with a plankton net (mesh 200 microns), in three climatic seasons: rains (July 2022), cold fronts (October 2022), and dry season (March 2023). Plankton tows were for 10 minutes each at a constant slow speed. The water filtered volume was calculated using a flowmeter General Oceanics®. Subsequently, the samples were placed in sterilized glass jars for further analysis.

For sediments, fifteen sites were selected in each of the zones (north: sites S2-S10; center: sites S13-S26; south: sites S28-S30) of the Bacalar Lake considering land use (Fig. 1). In each site, sediments were collected in triplicate, in the sublittoral zone using a metal can 10 cm in diameter, which was introduced into the sediment 5 cm. The sediment (approximately 500 g) was placed on aluminum foil and transported to the laboratory for further analysis.

Extraction of plastic items

To avoid possible contamination, samples were handled using nitrile gloves, cotton lab coats and clothing, samples were rinsed with H_2O_2 before analysis (Bogdanowicz et al., 2021; Yin et al., 2023). Additionally, all surfaces and equipment

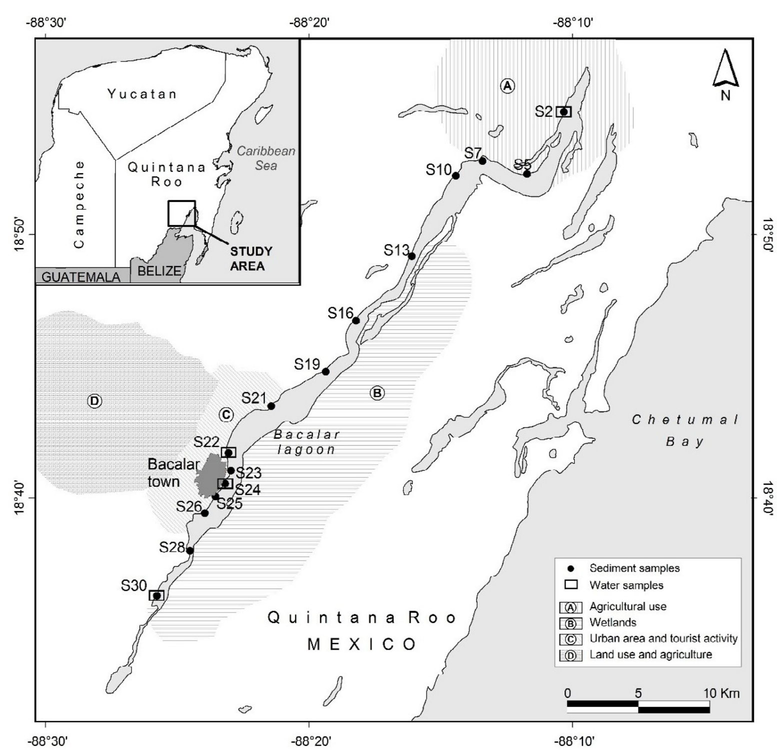

Figure 1. Location of sampling sites at Bacalar Lake and land use. Square: plankton tows; dot: sediment samples.*Localización de sitios de muestreo y uso del suelo en la Laguna de Bacalar. Cuadrados: arrastre de plancton; puntos: muestras de sedimento.*

were cleaned with ethanol and distilled H_2O before use and examined with a stereoscopic microscope to ensure the absence of external microplastics. Plastics collected in the water column were observed directly under the stereoscopic microscope and classified according to their shape, size, and color. The fibers were measured with an Axio Lab A1 Carl Zeiss microscope and ZEN 2.3 lite software.

For sediments, each sample was rinsed with oxygen peroxide and dried in the oven (65°C) for 24 hours. MP were separated from the sediments by flotation, based on density differences using a NaCl solution (ρ= 1.6 g/ml) in a bucket and stirred for 2 minutes; this process was repeated three times (Hidalgo-Ruz et al., 2012; Yin et al., 2023). The plastic particles in the samples were collected using a stereoscopic microscope at 40x. All plastics were separated with tweezers, dried, and sorted by morphology, fibers, pellets, rigid and semi-rigid fragments, films and color. Although this method is not the latest in technology, it has allowed the removal of microplastics successfully while having good control of background contamination (Bogdanowicz et al., 2021; Stile et al., 2021).

Chemical identification

Fourier transform infrared analysis (FTIR) (NICOLET iS5, Thermofisher Scientific), with total attenuated reflectance (ATR), was used to determine the microplastic chemical composition. Polymers were identified using the OMNIC software libraries for FTIR spectroscopy. The spectral assignment of the analyzed samples was made from coincidences higher than 80%. The equipment conditions were used following Borges-Ramírez et al. (2020), where the spectrum resolution was 4 cm^{-1}, with 3-5 scans per sample, automatic atmosphere adjustment: ignition, and baseline correction: advanced ATR correction. The ATR plate was cleaned with alcohol before each reading and at the end of a batch of readings to sterilize the surfaces. HR Hummel polymers and additives, HR rubber composite materials, and Sprouse polymers from ATR libraries were used in the identification. In the water, only 89 of the 296 items collected had the minimum requirements for analysis by the equipment, which represents a chemical identification rate of 30%. In the sediments, the fiber collected had to be grouped by color (red, black, blue and transparent) for chemical analysis, due to their small size and thickness.

Permutational multivariate analysis of variance (PERMANOVA) (Anderson, 2001) were performed to find significant differences in abundances between sites, seasons (rains, cold fronts, dry), color (black, blue, red, transparent), and shapes (fibers, films/fragments, beads/pellet). Analyses were performed using 9999 permutations under the reduced model in PRIMER Software v.6 (Clarke & Gorley, 2006).

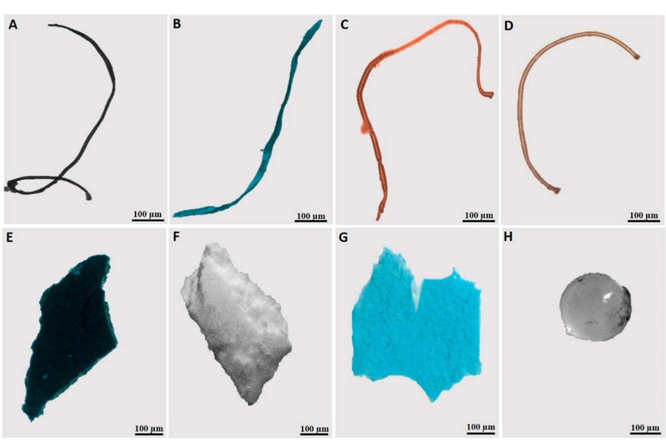

Figure 2. Microplastics morphology found at Bacalar Lake. A-D fibers (A: Black, B: Blue, C: Red, D: Transparent); E-G fragments (E: Black; F: White; G: Blue); H beads. *Morfología de los microplásticos en la Laguna de Bacalar. A-D fibras (A: Negra, B: Azul, C: Rojo, D: Transparente; E-G fragmentos (E: Negro, F: Blanco; G: Azul); H perlas.*

RESULTS

MP abundance, morphology, color, and size in surface water and sediments

In total, 296 plastic items were collected including fibers (black, blue, red, transparent), films/fragments (black, white, blue), and beads/pellet (Fig. 2). MP items were similar in July and October 2022 (77 particles each) but were more abundant in March 2023 (142 items). In July, 69.1% corresponded to fibers and 30.9% were films or fragments. In October 2022, fibers were more abundant (61%) than fragments (39%), while in March 2023, 95% of the items corresponded to fragments or films and only 5% were fibers. MP fragments and films were more abundant than fibers or pellets (67.9% vs 32.1%, respectively). Blue fibers were the most abundant with 63.2%, followed by transparent, black, and red fibers with 20%, 9.5% and 7.4% respectively (Fig. 3A; Table S1, supplementary information, available at https://www.limnetica.com/en/limnetica). In the case of films/fragments, white color was the most abundant (96%), followed by black (2%), blue (1.5%), and beads/pellet (0.5%) (Fig. 3B; Table S1). The amount of MP in water was less than 1 item/1000 m^3, with a mean of 0.50 items/1000 m^3 ± 0.41 items/1000 m^3. The higher abundance was detected at S22 and S24 (central area of the lake) in March 2023, with 0.72 and 0.94 items/1000 m^3, respectively. MP fragments size varied 1.42 to 4.71 mm, with a medium size 2.06 mm (Table S1). No significant differences in abundance were found between sites, climatic season, and forms; only MP color showed a significant difference (p = 0.001; Table 1).

Only fibers were found in sediments. A total of 667 MP was detected, with the highest abundance in July 2022 (274 items), followed by October 2022 and March 2023 (200 and 193 items, respectively) (Table S2, supplementary information, available at https://www.limnetica.com/en/limnetica). In July and October 2022, a dominance of transparent fibers was found (48.5% and 47.5%, respectively), followed by blue fibers (37.2% and 34.5%, respectively). In March, blue fibers dominated (54.9%), followed by transparent fibers (38.9%) (Fig. 3C, 3D, and 3E). Site S30 had a maximum of 0.88 items/kg registered in July 2022, and 0.40 during March 2023, while the rest of the stations had less than 0.04 items/kg. Sites

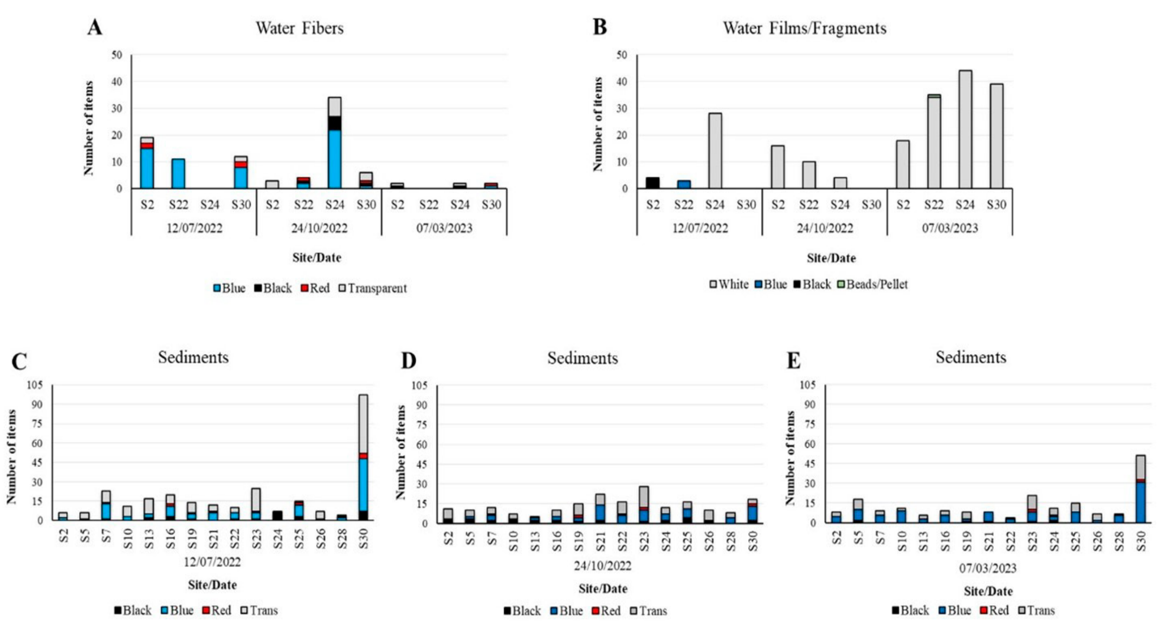

Figure 3. Abundance, morphology, and color of microplastics in surface water (3A, 3B) and sediments (3C, 3D, 3E) from Bacalar Lake. *Abundancia, morfología y color de los microplásticos en agua superficial (A, B) y sedimentos (C, D, E) en la Laguna de Bacalar.*

Table 1. Summary of the PERMANOVA tests in surface water and sediment samples. *Resumen de la prueba PERMANOVA en muestras de agua superficial y sedimentos.*

WATER					
Source	**df**	**SS**	**MS**	**Pseudo-F**	**P**
Site	3	0.501	0.170	0.150	0.930
Season	2	0.153	0.077	0.068	0.937
Color	6	37.697	6.283	9.077	**0.001**
Shape	2	4.445	2.222	2.052	0.136
SEDIMENT					
Source	**df**	**SS**	**MS**	**Pseudo-F**	**P**
Site	14	19.238	1.374	1.255	0.570
Season	2	1.675	0.838	0.765	0.677
Color	3	69.290	23.097	21.099	**0.031**

S23, S25, located at Bacalar town, and S30 in the south of Lake with tourist activities showed more MP abundance. The mean size of microplastics in sediments was 1.67 mm, with a range of 266 to 6.45 mm (Table S2). Like microplastics in the water, significant differences were found between color ($p = 0.031$), but not between sites or seasonality (Table 1).

Chemical identification

A total of 18 plastic polymers were identified in MP fibers and fragments in water and sediments. Cellophane (CE) and the copolymers Polystyrene: vinylidene chloride (PS: PVC) and Poly (ethylene: propylene: diene) (EPDM) were found in the highest number, with percentages of 40%, 38% and 12%, respectively. The remaining 10% of the polymer diversity was represented by Alkyd resin (ALK), Poly (vinylidene fluoride) (PVDF) and Polyamide 6 + Polyamide 6.6 (PA6+PA6.6) with abundances < 4%; as well as Poly (acrylonitrile: MMA) (PAN: MMA), Urethane alkyd (ALK-PU), Poly (styrene) atactic (PS a), Polyethylene (PE), Polyester (PES), Polyethylene Marlex catalyst (HPDE Marlex), Polyester tere-iso phthalate (UPR), Poly methyl methacrylate (PMMA), Polystyrene film (PS film), Acrylic (Ac), Poly(acrylic acid) (PAA) and Polyethylene vinyl alcohol (PVOH), with abundances < 1%. In the water column, 86% of the MP corresponded to fibers composed of CE, PS: PVC and EPDM (copolymer PE: PP), while fragments were composed of ALK, PVDF and PA6+PA6.6 (Fig. 4A). In the sediments, where only fibers were detected, 87% were polymers PS: PVC and CE, and the rest EPDM (Fig. 4B).

Low-density polymers predominate in the water column (e.g., PE, PP, PA), while high-density polymers predominate in the sediments (e.g., PS, PVC). Regarding seasonal variability, it was observed that the greatest diversity of polymers in the water column was recorded during October (cold front season) with 15 types of plastics (Fig. 4C), followed by the dry (March) and rainy seasons (July) with 9 (Fig. 4D) and 8 polymers (Fig. 4E), respectively. However, only PS: PVC, CE and EPDM accounted for 64-82% of the MP particles collected during the rainy season and cold fronts; while in the dry season, 60% of the plastic particles corresponded to ALK, PA6+PA6.6 and PVDF.

DISCUSSION

Microplastics are present in all aquatic environments on the planet, and this is a cause for concern regarding water quality, as well as the effects of microplastics on biota (Loayza et al., 2022; Yin et al., 2023).

MP can reach different levels of an aquatic system, including water column, sediments, and biota. The concentration, morphology and type of MP particles will be correlated with the size of the human population and economic activities in each region (Li et al., 2020), which is supported

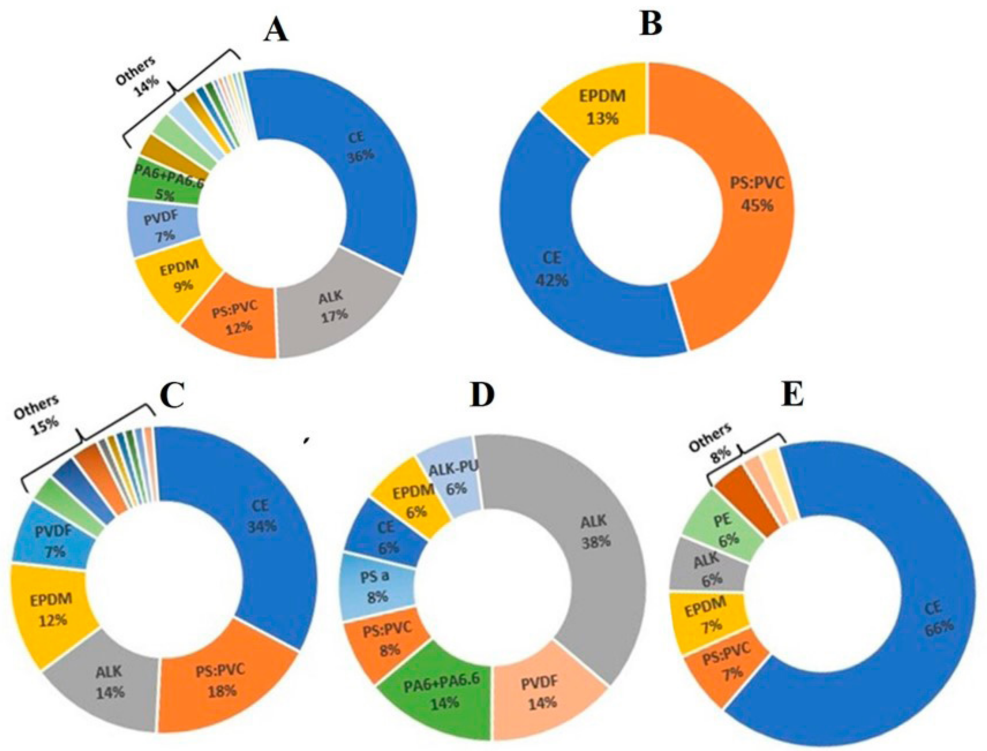

Figure 4. Percentages of polymer types found in water (A) and sediments (B) during Cold Fronts (C), Dry (D), and Rainy seasons (E) from Bacalar Lake. Polymers with percentages lower than 5% are labeled as "others" which correspond to: PAN: MMA, PA6+PA6.6, HPDE, PAA, ALK-PU, UPR, PMMA, PES, PS film, PVOH, Ac. *Porcentajes de los tipos de polímeros en agua (A) y sedimentos (B) durante los frentes fríos (C), Secas (D) y lluvias (E) en la Laguna de Bacalar. Polímeros con porcentajes menores que 5% son etiquetados como otros y corresponden a; PAN: MMA, PA6+PA6.6, HPDE, PAA, ALK-PU, UPR, PMMA, PES, PS filme, PVOH, Ac.*

by our results, finding the highest amount of MP in sites close to the city of Bacalar (center section) and with tourist activities (south section). In Asia, dominant MP morphology in lakes were fibers (64.5%) followed by fragments (22.6%), 12.1% corresponded to films and 0.8 % were pellets (Yang et al., 2022), while in Europe, lakes contained more fragments (68%) than fibers (22%), with only 7.2% foams and 0.8% pellets (Uurasjärvi et al., 2020).

In the water surface of Bacalar Lake we found all MP morphologies, but fragments were more abundant (67%) than fibers (32%) or pellets (< 1%). It is likely that due to the mesh opening of the net, microplastics smaller than 200 microns have been lost, but we believe that there would be very few elements. The predominance of those plastic fragments might be related to the decomposition of macro and mesoplastics occurring in the vicinity of the lake, or also due to poor management of solid waste and uncontrolled landfill in the municipality. Fibers could originate from the washing water and clothes of tourists who practice water activities in Bacalar mainly in the southern section of the lake where tourism is more abundant. A similar scenario was observed in a tourist beach in Huatulco by Retama et al. (2016). The presence of some pearls in our plankton tows could originate from the use of personal care products (Gorman et al., 2020). The diversity of MP colors could indicate the variety contamination sources, mainly from secondary sources, like degraded MP product of human activities (Li et al., 2020). In Bacalar, white fragments and blue fibers were the most abundant items, and their presence is product of fragmentation of large plastics in the area, whereas blue fibers could be product of washing synthetic clothes (Retama et al., 2016; Yang et al., 2022).

The MP concentrations in water surface vary on each system, as they are affected by their geographic location, economic development, and the presence of high levels of organic matter in the water column (Ding et al., 2022). In China 1.81-34 000 items/m^3 was informed (Wang et al., 2018; Xiong et al., 2018; Yin et al., 2019; Picó et al., 2020). Microplastic abundances in Al-Asfar Lake and Al-Hubail Lakes in Saudi Arabia show levels reaching 700-9000 items/m^3 (Picó et al., 2020). In contrast, studies in Italy and Finland revealed relatively low MP concentrations in water (0.05-8.82 and 0.003-0.66 items/m^3, respectively). These abundances are higher than those recorded in the water surface of Bacalar (average < 0.0005 items/m^3), which could be explained by the low population inhabiting the city of Bacalar (12 527 people), although it receives 180 000 tourists every year (INEGI, 2020). It is probable that MP concentration in water is due to release of fibers product for washing in hotels. However, similar low concentrations have been considered pollution in the Uganda portion of Lake Victoria (0.02-0.14 particles/m^3) (Egessa et al., 2020), as well as in Guanabara Bay, Brazil (0.6-11 items/m3) (Figueiredo & Vianna, 2018).

According to previous studies a lot of microplastics were accumulated in sediments of rivers, lakes, and other reservoirs (see Fernandes et al., 2022; Yin et al., 2023). Although there is little data on microplastics in sediments from epicontinental systems, abundances are highly variable (Li et al., 2021; Ehlers et al., 2022; Yin et al., 2023). For example, in Amazon River sediments, Gerolin et al. (2020) reported 31-8178 items/kg, Shruti et al. (2019) recorded 900 ± 346.12 items/kg in the Valsequillo dam and 833.33 ± 80.79 items/kg in the Atoyac River, Mexico. In contrast, Bacalar Lake presented a concentration of less than 1 item/kg in the sediments. On the other hand, unlike what was reported by Fernandes et al. (2022) for freshwater sediments from the Americas, where MPs were composed of fibers (37.0%), fragments (31.8%), foams (29.9%), films and pellets (< 1%), in Bacalar only the presence of fibers was observed.

In many investigations about sediment MP abundance, the transparent fibers and fragments are the most frequent (Li et al., 2021; Fernandes et al., 2022). In general, transparent microplastics derived from disposable plastics, such plastic bags, commodity packaging and bottles, have a short lifetime (Yang et al., 2021). In Bacalar, white and transparent fibers were more frequent items in sediments, and it could be related to an inadequate disposal of plastic waste in the adjacent areas to the lake.

Chemical identification

The predominance of PP, PE, PS, PVC, and CE polymers in Bacalar Lake is due to their wide use, which represent 80-90% of global plastic production (Ríos-Mendoza & Balcer, 2019; Wang et al., 2021) and are the most reported in aquatic environments in Latin America (Celis-Hernández et al., 2023; Moreno-Rodríguez et al., 2024). Some compounds like Cellophane could be associated with high organic matter concentration derived from plants (Ding et al., 2022). Among the plastic products in which these polymers are found are food packaging, reusable and disposable bags and short-life personal care items, waterproofing enamels and paints, pipes, thermal insulators and electrical cables, housings of domestic and cellular appliances, clothing, and other textiles; while PA is used in fishing lines, ropes, and packaging (Hengstmann et al., 2021; Yang et al., 2021). This chemical composition of MP was like that reported in the freshwater lakes of Dongting, Wuliangsuhai, and Songshan in China (Mao et al., 2021; Tang et al., 2022), Tollense river in Germany (Hengstmann et al., 2021), and in other freshwater systems around the world (Lu et al., 2021).

The spatio-temporal distribution of MP in water bodies is associated with seasonal climate changes, hydrodynamics, anthropogenic influence, and MP characteristics (e.g., polymer density) (Garcés-Ordóñez et al., 2022). The greater diversity of plastic polymers recorded during the cold front season may be due to the characteristics of rain and wind, which favor the surface entrainment of particles from the agricultural zone north of the lake and from the Mennonite agricultural area and the city of Bacalar in the central part of the lake, which has limited and inadequate wastewater treatment; as well as the intense tourist activity in the southern part of the system (Fig.1). This is a behavior like that reported in Borges-Ramírez et al. (2020) for the Bay of Campeche, Mexico, and by Rodrígues et al. (2018) in the Antuã River, Portugal.

Our data showed significant differences in MP color, but not between sites, climatic periods, or seasons, so there are apparently no major effects of material carry-over due to rainfall. Although the abundance of MP at Bacalar Lake is lower than most of the studies carried out in other freshwater regions, the MP presence is related to human activities, since the highest abundances of MP were found in nearby sites to spas, docks construction, boat traffic, and urban areas influencing sites such as S5, S7, S24, and S26. This is more evident in the water surface samples than in the sediment samples, maybe due to the sample processing method.

CONCLUSIONS

The presence of microplastic in freshwater has also caused great worries from the public; however, the current information on the abundance and impact of microplastics in freshwater systems is still limited linked to that of marine environments. The abundance of microplastics in Bacalar Lake can be considered low and in accordance with urban development in the area. A greater presence of fragments and fibers and predominance of some polymers indicates a secondary origin, product of fragmentation of larger components such as bags, food packaging, or synthetic fibers product of washing clothes, probably from the hotels adjacent to the Bacalar Lake. There is a greater abundance of microplastics in the lake, in sites near urban centers or where tourism intensifies the most, which is the south-central part of Bacalar Lake.

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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.

DATA AVAILABILITY

The datasets used during the current study are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

A.J.N.: Writing-original draft, Conceptualization, Methodology, Formal analysis, Supervision, Resources; A..A.V.E.: Methodology, Formal analysis, Data Curation, Writing - Review & Editing. T.A.L.: Formal analysis, Resources, Writing - Review & Editing. J.R.O.: Formal analysis, Writing - Review & Editing. M.M.B.R.: Formal analysis, Writing - Review & Editing.

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