

Polymer Types and Plastic-Associated Materials Identified in Marine Base Creek, Port Harcourt, Nigeria

Muideen Olaitan Taleat¹, Reuben Nwomandah Okparanma², Silas Ovua Nkakini³, Asinyetogha Hikiah Igoni⁴
Department of Agricultural and Environmental Engineering, Rivers State University, Port Harcourt, Nigeria

Corresponding Author's E-mail : mdtaleat@yahoo.com

Abstract: Microplastic contamination of urban creeks is an emerging environmental concern, particularly in rapidly urbanizing coastal cities where wastewater, runoff, household waste and industrial activities converge. This study identified and classified microplastic-associated materials present in Marine Base Creek, Port Harcourt, Nigeria, under decreasing- and increasing-tide conditions. Surface-water samples were collected from two sections of the creek at 0, 5, 10, 15, 20, 25, 30, 35, 40 and 45 m, with three replicates at each location. Samples were extracted using density separation with an ultrasonic bath and analysed using Fourier Transform Infrared Spectroscopy with a diamond attenuated-total-reflectance accessory. Spectra were recorded at 4 cm^{-1} resolution with 64 scans and matched against Hummel polymer and Nicolet spectral libraries. Identified particles were additionally examined microscopically, and their type and size were recorded. Eight recurring material categories were identified across the studied locations and tidal conditions: polyethylene, polypropylene, polyethylene terephthalate, polystyrene, acrylic fibre, dioctyl terephthalate, polybrominated diphenyl ether and tetrabromobisphenol-A. Polyethylene and polypropylene were reported as the most frequently detected polymer types, while polyethylene terephthalate was also prevalent. Acrylic fibre indicated a potential contribution from textile-related releases, whereas dioctyl terephthalate, polybrominated diphenyl ether and tetrabromobisphenol-A indicated the presence of plastic-associated additives or additive-related compounds. The simultaneous occurrence of several polymer classes demonstrates that Marine Base Creek receives microplastic inputs from multiple anthropogenic pathways. The findings provide a baseline polymer profile for the creek within this urban brackish waterway and support source-oriented monitoring, pollution prevention and future assessment of microplastic fate in Port Harcourt urban waterways.

Keywords: microplastics; polymer identification; FTIR-ATR; Marine Base Creek; Port Harcourt.

1. Introduction

Plastic production and consumption have expanded rapidly because plastics are lightweight, durable, versatile and inexpensive. These same properties make plastic residues persistent after disposal and facilitate their fragmentation into smaller particles in terrestrial and aquatic environments (Andrady, 2011; Andrady, 2017; Lambert et al., 2014). Microplastics are commonly considered plastic particles smaller than 5 mm and may be introduced directly as manufactured small particles or generated secondarily by weathering and fragmentation of larger plastic products (GESAMP, 2016; Wagner & Lambert, 2018).

Microplastics occur in marine, freshwater, estuarine and urban aquatic environments and can be transported between environmental compartments by runoff, wastewater, wind and river flow (Wagner et al., 2014; Strungaru et al., 2019). Urban waterways are particularly important because they receive diffuse and point-source inputs from households, commercial activities, transportation, wastewater and poorly managed solid waste (McCormick et al., 2016; Murphy et al., 2016; Stovall & Bratton, 2022). Rivers and creeks can subsequently act as both temporary sinks and transport pathways to coastal waters (Rech et al., 2014; Moore et al., 2011).

The polymer composition of microplastics provides useful information about potential sources. Polyethylene and polypropylene are widely used in packaging, containers, bags, ropes and household products, whereas polyethylene terephthalate is associated with beverage bottles and synthetic fibres. Fibres may originate from textiles and wastewater, and plastic-associated additives may indicate more complex industrial, electronic or consumer-product inputs. Studies of freshwater systems have reported PE, PP, PET, PS and polyester-type materials among commonly encountered polymers (Khan et al., 2018; Migwi et al., 2020; Toumi et al., 2019).

Reliable polymer identification is important because visual classification alone cannot adequately distinguish polymer types. Spectroscopic techniques, particularly Fourier Transform Infrared Spectroscopy and Raman spectroscopy, are widely used for chemical confirmation of suspected microplastics (Hidalgo-Ruz et al., 2012; Mintenig et al., 2016; Lefebvre et al., 2019). FTIR-based identification compares the infrared spectrum of an unknown particle with reference spectra and can therefore provide a more defensible classification than morphology alone.

Nigeria has increasing plastic consumption and persistent challenges in waste management, while studies have documented microplastics in inland waters and aquatic organisms. Akindele et al. (2019, 2020) demonstrated microplastic occurrence in Nigerian freshwater systems, and Enyoh (2019) highlighted the need for increased attention to microplastic pollution. In the Niger Delta, high population density, intense commercial activity, extensive waterways and industrial development create conditions that may facilitate plastic transfer to aquatic systems (Sojinu et al., 2010).

Marine Base Creek is an urban waterway within Port Harcourt where anthropogenic activities occur close to the creek. There is dearth of information in literature on the polymer types and plastic-associated materials identified in Marine Base Creek, Port Harcourt. Hence, there is need for this study. Therefore, this study aims to identify and classify the types of microplastics present in Marine Base Creek at different sampling points in the study area under decreasing- and increasing-tide conditions.

2. Materials and Methods

2.1 Study area and sampling design

The study was conducted in Marine Base Creek within Port Harcourt metropolis, Rivers State, in the Niger Delta of southern Nigeria. The sampling design comprised two creek sections. Ten distances (0, 5, 10, 15, 20, 25, 30, 35, 40 and 45 m) were established in each section, giving 20 sampling locations, with three replicate samples collected at each location. One section represented the decreasing-tide sampling condition and the other the increasing-tide condition. The total design therefore comprised 60 replicate observations. The source document states that the sampling locations were selected because of anthropogenic activities and use of the creek by nearby residents.

2.2 Surface water sampling

Surface-water samples were collected from a boat moving along the creek in the direction of water flow. Samples were collected in triplicate at each location to reduce error associated with non-uniform distribution. Samples were stored in cleaned containers and transported in a cooler protected from direct sunlight. The source document notes that container material, field blanks, recovery tests and some contamination-control details were not fully documented; these limitations should be resolved against the original laboratory records before submission.

2.3 Microplastics extraction and identification

Extraction was reported as a density-separation procedure adapted from Rodrigues et al. (2018), with an ultrasonic bath introduced to improve separation. The source report contains a methodological inconsistency because the stated sampling design concerns surface water whereas part of the extraction description is sediment-oriented.

Following extraction, suspected particles were transferred to weighing paper and examined using a Nicolet iS50 Fourier Transform Infrared Spectroscopy instrument equipped with a diamond ATR accessory. Reference spectra were stored in spectral libraries. Individual suspected particles were placed on the diamond accessory with sufficient pressure for optical contact, and spectra were recorded at 4 cm^{-1} resolution using 64 scans. Polymer/material identification was based on comparison with the Hummel polymer and Nicolet databases. Identified particles were photographed with a Leica M125 metallographer, while particle type and size were recorded.

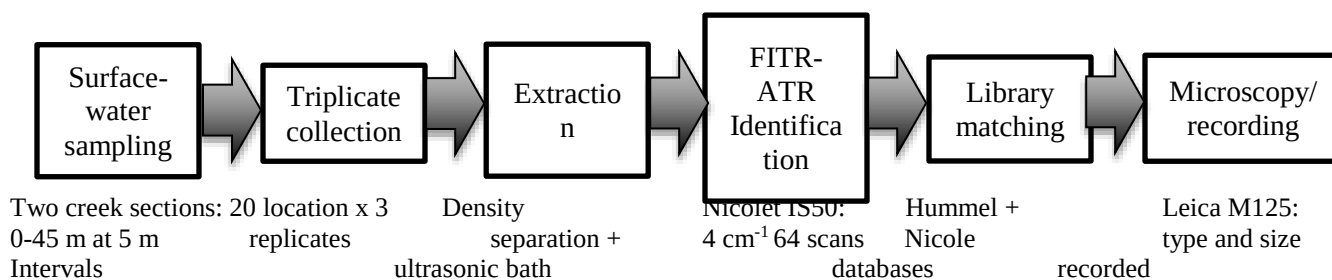


Figure 1: Analytical workflow used for identification and classification of microplastic-associated materials

2.4 Classification framework

For journal presentation, the eight reported materials were separated into three interpretive groups: (i) primary polymer classes (PE, PP, PET and PS); (ii) a synthetic polymer fibre (acrylic fibre); and (iii) plastic-associated additives or additive-related compounds (DOTP, PBDE and TBBPA). This classification follows the chemical identities reported by the study and avoids treating additive-related compounds as if they were conventional bulk polymers.

3. Results and Discussion

Table 1: Laboratory Results During Decreasing Tide

Sample Location, m	Microplastics, mg/kg							
	Polyeth ylene	Polyethylene terephthalate	Diethyl terephthalate	Polybrominated diphenyl ether	Tetrabromobis phenol A	Polypro pylene	Acrylic fiber	Polysty rene
0	1342	2074	1464	2928	2318	2196	1830	1586
5	1223.31	1823.47	1356.41	2651.11	2138.07	1963.83	1623.82	1368.5
10	1110.2	1614.06	1204.14	2182.58	1869.04	1743.38	1396.9	1118.7
15	1059.96	1339.47	963.16	2175.58	1593.57	1537.91	1167.65	1051.4
20	918.66	1112.64	891.82	1777.54	1398.12	1248.06	946.72	9
25	784.08	872.41	669.13	1519.76	1170.07	994.62	833.69	899.14
30	695.4	740.54	523.38	1072.38	952.82	777.14	633.18	828.85
35	582.01	649.77	373.89	722.37	619.52	630.41	479.16	685.64
40	520.94	417.24	213.5	453.84	428.22	506.3	267.18	573.54
45	484	242	121	121	242	363	241	385.52
								242

Table 2: Laboratory Results During Increasing Tide

Sample Location, m	Microplastics, mg/kg							
	Polyeth ylene	Polyethylene terephthalate	Diethyl terephthalate	Polybrominated diphenyl ether	Tetrabromobis phenol A	Polypro pylene	Acrylic fiber	Polysty rene
0	1100	1700	1200	2400	1900	1800	1500	1300
5	1011	1507	1121	2191	1767	1623	1342	1131
10	910	1323	987	1789	1532	1429	1145	917
15	876	1107	796	1798	1317	1271	965	869
20	753	912	731	1457	1146	1023	776	737
25	648	721	553	1256	967	822	689	685
30	570	607	429	879	781	637	519	562
35	481	537	309	597	512	521	396	474
40	427	342	175	372	351	415	301	316
45	400	200	100	100	200	300	237	217

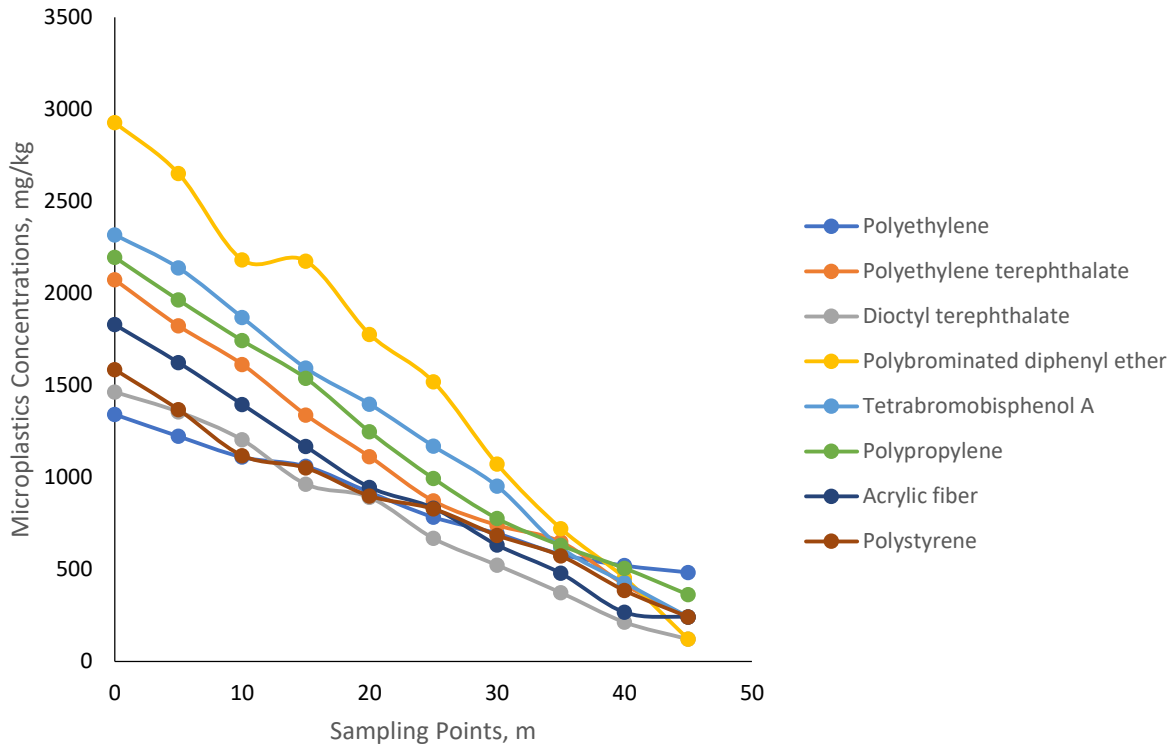


Figure 1: Microplastics Concentration during Decreasing Tide at Sampling Points

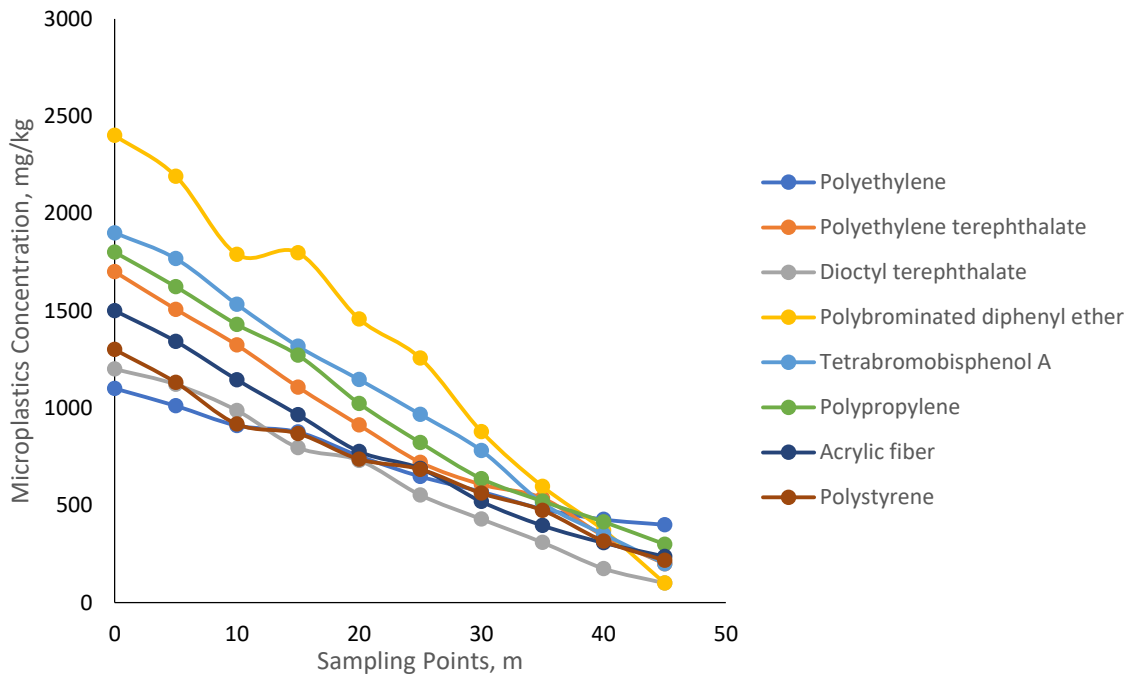


Figure 2: Microplastics Concentration during Increasing Tide at Sampling Points

Table 3. Classification and interpretation of the eight material categories identified in Marine Base Creek

Identified material	Category used in this manuscript	Common product/source association	Evidence in study
Polyethylene (PE)	Polymer	Packaging, bags, containers and household plastics	Detected under both tidal conditions; among most frequent
Polypropylene (PP)	Polymer	Packaging, containers, ropes and household plastics	Detected under both tidal conditions; among most frequent
Polyethylene terephthalate (PET)	Polymer	Beverage bottles and synthetic textile materials	Prevalent at studied points
Polystyrene (PS)	Polymer	Foam/packaging and consumer products	Detected under both tidal conditions
Acrylic fibre	Synthetic polymer fibre	Textile-related materials and washing effluent	Detected under both tidal conditions
Diethyl terephthalate (DOTP)	Plastic-associated additive	Plasticizer associated with polymer products	Detected in laboratory results
Polybrominated diphenyl ether (PBDE)	Plastic-associated additive/compound	Flame-retardant-related applications and treated polymers	Detected; interpreted as evidence of complex anthropogenic inputs
Tetrabromobisphenol-A (TBBPA)	Plastic-associated additive/compound	Flame-retardant-related applications	Detected; interpreted as evidence of complex anthropogenic inputs

4.2 Identification of conventional polymer classes

The dominance of PE and PP is consistent with their widespread use in consumer and packaging products. Polyethylene and polypropylene are among the polymers commonly reported in freshwater and urban aquatic environments, reflecting their extensive manufacture and use (Khan et al., 2018; Migwi et al., 2020). Similar polymer profiles have been reported in Nigerian aquatic systems, where PE, PP, PET and other common polymers have been associated with domestic and anthropogenic sources (Akindele et al., 2019, 2020; Enyoh, 2019).

PET detection is also environmentally plausible because beverage bottles and polyester-type textile materials are widespread sources of plastic residues. The occurrence of PET alongside PE and PP indicates that the creek receives inputs from several classes of consumer products rather than from a single source. Studies in rivers and lakes have similarly found mixtures of PE, PP, PET and PS, demonstrating that polymer composition can reflect multiple source categories (Wang et al., 2016; Di & Wang, 2017; Leslie et al., 2017).

Polystyrene was among the identified materials. Its presence is consistent with the widespread use of polystyrene in packaging and other consumer applications and with its reported occurrence in aquatic environments (Hammer et al., 2012; Savoca et al., 2019). The simultaneous identification of four major commodity polymers (PE, PP, PET and PS) therefore provides evidence of a chemically diverse microplastic assemblage in Marine Base Creek.

4.3 Acrylic fibre and additive-related compounds

Acrylic fibre was identified alongside the commodity polymers. Synthetic fibres are important microplastic contributors because textile washing and wastewater pathways can release fibres to aquatic environments. Murphy et al. (2016) and Talvitie et al. (2015) documented wastewater-related microplastic releases, while Blair et al. (2019) emphasized that fibres in urban freshwater systems may arise from sewage and other pathways including atmospheric deposition and in-stream transport. The occurrence of acrylic fibre in Marine Base Creek is therefore compatible with the urban setting and the presence of household activities around the creek.

DOTP, PBDE and TBBPA require a more careful interpretation. They were listed in the source study among the eight identified microplastic materials, but chemically they are better described as plastic-associated additives or additive-related compounds rather than conventional bulk polymer backbones. PBDEs and TBBPA are associated with flame-retardant applications, whereas DOTP is used as a plasticizer. Their identification suggests that the contaminant mixture may include particles or residues associated with treated plastics and consumer/industrial products. This interpretation broadens the source picture beyond household packaging to potentially include electronic products, treated polymers and industrial materials.

The presence of these compounds is important because additives can influence the environmental behaviour and toxicological relevance of plastic particles. Microplastics can interact with other contaminants and biological systems, and their environmental significance is not determined solely by particle abundance (Galloway et al., 2017; Sharma & Chatterjee, 2017). Consequently, chemical identification of the material classes provides information that simple visual counting cannot provide.

4.4 Consistency across tidal conditions

The supplied results indicate that the same eight material categories were detected during both decreasing- and increasing-tide conditions. Thus, the first objective demonstrates compositional persistence across the two hydrodynamic states, even though the subsequent objectives showed that concentrations varied with tidal condition. The source report specifically states that all microplastic types identified during decreasing tide were also detected during increasing tide.

This observation is significant because it separates composition from abundance. Tidal dynamics may redistribute particles and alter concentrations at individual locations, but the persistence of the same material categories suggests that the creek receives a recurring mixture of anthropogenic plastic inputs. Similar studies have reported spatially variable microplastic composition linked to wastewater, urban runoff and other sources (Mani et al., 2015; Rech et al., 2014).

The source document also reports that the creek contains a range of polymer materials reflecting complex anthropogenic activity. This is consistent with the general observation that urban streams can receive multiple microplastic pathways, including wastewater, stormwater and direct litter inputs (McCormick et al., 2016; Stovall & Bratton, 2022).

4.5 Comparison with Previous Studies

The polymer profile obtained in Marine Base Creek broadly agrees with studies from African and international freshwater environments. Akindele et al. (2019) documented microplastics in Nigerian freshwater gastropods, while Akindele et al. (2020) demonstrated ingestion of microplastics by freshwater insects in Gulf of Guinea tributaries. Toumi et al. (2019) identified microplastics in streams surrounding the Bizerte lagoon, and Migwi et al. (2020) reported microplastics in Lake Naivasha. These studies collectively demonstrate that PE, PP, PET and other polymers occur widely in freshwater systems.

The present identification of eight material categories is also compatible with the broader literature emphasizing the diversity of microplastic sources. GESAMP (2016) and Wagner and Lambert (2018) distinguish primary and secondary pathways, while Hidalgo-Ruz et al. (2012) emphasize the need for analytical identification to improve comparability among studies. The use of FTIR-ATR in the present work is therefore an appropriate approach for moving from suspected particles to chemically supported material classification.

Nevertheless, comparisons should be made cautiously because sampling units, extraction procedures, size cut-offs, analytical instruments and reporting conventions differ among studies. The present source document reports concentrations in mg/kg, although the sampled matrix is described as surface water. This matrix-unit inconsistency should be clarified using the original laboratory record before the manuscript is submitted to a journal. The polymer identification itself is retained because the source explicitly reports FTIR-based identification and library matching.

4.6 Environmental Significances

The identification of multiple polymer classes and plastic-associated compounds indicates that Marine Base Creek is exposed to diverse anthropogenic plastic inputs. PE, PP, PET and PS are persistent materials with established environmental occurrence, while synthetic fibres provide an additional pathway associated with textiles. The detection of additive-related compounds indicates that the chemical composition of contamination may be more complex than a simple mixture of commodity plastics.

This finding is environmentally relevant because microplastics can be ingested by aquatic organisms and transferred through food webs. Farrell and Nelson (2013), Setälä et al. (2014) and Rochman et al. (2015) provide evidence that plastic particles can enter aquatic trophic pathways and may occur in organisms of ecological and human-consumption importance. However, the present objective did not investigate biological uptake, toxicity or human exposure, and no such outcomes should be inferred directly from polymer identification alone.

The principal value of Objective 1 is therefore baseline characterization. Establishing the polymer profile allows subsequent concentration, spatial and transport analyses to be interpreted in relation to possible sources. It also provides a reference for future monitoring and source-control measures in Port Harcourt urban waterways.

4. Conclusion

- i. The laboratory identification programme established eight recurring microplastic-associated material categories in Marine Base Creek: polyethylene, polypropylene, polyethylene terephthalate, polystyrene, acrylic fibre, dioctyl terephthalate, polybrominated diphenyl ether and tetrabromobisphenol-A.
- ii. PE and PP were reported as the most frequently detected conventional polymers, while PET was also prevalent. The profile indicates inputs from several classes of consumer and urban activities rather than a single source.
- iii. Acrylic fibre provides evidence consistent with textile-related contributions, whereas DOTP, PBDE and TBBPA indicate the presence of plastic-associated additives or additive-related compounds and therefore a more chemically complex contamination profile.
- iv. The same eight material categories were reported under both decreasing- and increasing-tide conditions, demonstrating persistence of the contaminant composition even when hydrodynamic conditions changed their distribution.
- v. FTIR-ATR spectroscopy with spectral-library matching provided the principal chemical identification method and, together with microscopy, supplied a stronger basis for classification than visual examination alone.

References

- Akindele, E. O., Ehlers, S. M., & Koop, J. H. E. (2019). First empirical study of freshwater microplastics in West Africa using gastropods from Nigeria as bioindicators. *Limnologia*, 78, 125708. <https://doi.org/10.1016/j.limno.2019.125708>.
- Akindele, E. O., Ehlers, S. M., & Koop, J. H. E. (2020). Freshwater insects of different feeding guilds ingest microplastics in two Gulf of Guinea tributaries in Nigeria. *Environmental Science and Pollution Research*, 27, 33373–33379.
- Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin*, 62(8), 1596–1605.
- Andrady, A. L. (2017). The plastic in microplastics: A review. *Marine Pollution Bulletin*, 119(1), 12–22.
- Blair, R. M., Waldron, S., Phoenix, V. R., & Gauchotte-Lindsay, C. (2019). Microscopy and elemental analysis characterisation of microplastics in sediment of a freshwater urban river in Scotland, UK.
- Di, M., & Wang, J. (2017). Microplastics in surface waters and sediments of the Three Gorges Reservoir, China.
- Enyoh, E. (2019). Microplastic pollution in Nigeria: A call for concern. Chemical Society of Nigeria, Imo State Chapter meeting.
- Farrell, P., & Nelson, K. (2013). Trophic level transfer of microplastic: *Mytilus edulis* (L.) to *Carcinus maenas* (L.). *Environmental Pollution*, 177, 1–3.
- Galloway, T. S., Cole, M., & Lewis, C. (2017). Interactions of microplastic debris throughout the marine ecosystem. *Nature Ecology & Evolution*, 1(5), 0116. <https://doi.org/10.1038/s41559-017-0116>.
- Hammer, J., Kraak, M. H., & Parsons, J. R. (2012). Plastics in the marine environment: The dark side of a modern gift. *Reviews of Environmental Contamination and Toxicology*, 220, 1–44.
- Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., & Thiel, M. (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. *Environmental Science & Technology*, 46(6), 3060–3075.
- Khan, F. R., Mayoma, B. S., Biginagwa, F. J., & Syberg, K. (2018). Microplastics in inland African waters: Presence, sources, and fate. In *The Handbook of Environmental Chemistry* (pp. 101–124). Springer.
- Lambert, S., Sinclair, C. J., & Boxall, A. B. A. (2014). Occurrence, degradation and effects of polymer-based materials in the environment. *Reviews of Environmental Contamination and Toxicology*, 227, 1–53. https://doi.org/10.1007/978-3-319-01327-5_1.

- Lefebvre, C., Saraux, C., Heitz, O., Nowaczyk, A., & Bonnet, D. (2019). Microplastic FTIR characterization and distribution in the water column and digestive tracts of small pelagic fish in the Gulf of Lions. *Marine Pollution Bulletin*, 142, 510–519.
- Leslie, H. A., Brandsma, S., van Velzen, M. J. M., & Vethaak, A. D. (2017). Microplastics en route: Field measurements in the Dutch river delta and Amsterdam canals, wastewater treatment plants, North Sea sediments and biota.
- Mani, T., Hauk, A., Walter, U., & Burkhardt-Holm, P. (2015). Microplastics profile along the Rhine River.
- McCormick, A. R., Hoellein, T. J., London, M. G., Hittie, J., Scott, J. W., & Kelly, J. J. (2016). Microplastic in surface waters of urban rivers: Concentration, sources, and associated bacterial assemblages. *Ecosphere*, 7(11), e01556. <https://doi.org/10.1002/ecs2.1556>.
- Migwi, F. K., Ogunah, J. A., & Kiratu, J. M. (2020). Occurrence and spatial distribution of microplastics in the surface waters of Lake Naivasha, Kenya. *Environmental Toxicology and Chemistry*, 39, 765–774.
- Moore, C. J., Lattin, G. L., & Zellers, A. F. (2011). Quantity and type of plastic debris flowing from two urban rivers to coastal waters and beaches of Southern California. *Journal of Integrated Coastal Zone Management*, 11(1), 65–73.
- Murphy, F., Ewins, C., Carbonnier, F., & Quinn, B. (2016). Wastewater treatment works as a source of microplastics in the aquatic environment. *Environmental Science & Technology*, 50(11), 5800–5808. <https://doi.org/10.1021/acs.est.5b05416>.
- Rech, S., Macaya-Caquilpán, V., Pantoja, J. F., Rivadeneira, M. M., Jofre Madariaga, D., & Thiel, M. (2014). Rivers as a source of marine litter: A study from the SE Pacific. *Marine Pollution Bulletin*, 82(1–2), 66–75.
- Rochman, C. M., Tahir, A., Williams, S. L., et al. (2015). Anthropogenic debris in seafood: Plastic debris and fibers from textiles in fish and bivalves sold for human consumption. *Scientific Reports*, 5, 14340.
- Rodrigues, M. O., Gonçalves, A. M. M., Nogueira, H., Marques, J. C., & Abrantes, N. (2018). Effectiveness of a methodology of microplastics isolation for environmental monitoring in freshwater systems.
- Savoca, S., Capillo, G., Mancuso, M., et al. (2019). Microplastics occurrence in the Tyrrhenian waters and in the gastrointestinal tract of two congener species of seabreams. *Environmental Toxicology and Pharmacology*, 67, 35–41.
- Setälä, O., Fleming-Lehtinen, V., & Lehtiniemi, M. (2014). Ingestion and transfer of microplastics in the planktonic food web. *Environmental Pollution*, 185, 77–83.