

Occurrence and Distribution of Microplastics in African Aquatic Ecosystems: Part 1—Freshwater Systems

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Abstract

Microplastics are ubiquitous in aquatic and terrestrial environments worldwide and have emerged as a major environmental concern. This manuscript reviews the literature published between 2017 and 2026 on the occurrence of microplastics in African freshwater ecosystems. It examines how local land use, anthropogenic activities, and wastewater treatment plants, as well as the geomorphological characteristics of rivers and lakes and seasonal hydrological dynamics, influence the distribution of microplastics.

Keywords

Plastic Pollution, Microplastics, Freshwater Environment, Wastewater Treatment Plants, Africa

1. Introduction

Over the past two decades, microplastics (MPs), defined as plastic particles smaller than 5 mm, have come into focus as pollutants that contaminate ecosystems worldwide. Their presence has been with us for a much longer time and is strongly associated with the rise of the plastic industry and the usage of polymers. Scientific reports on the occurrence and impact of MPs in the environment have emerged slowly in the late 1970s [1], with the definition of MPs stemming from a paper published in 2004 [2], whereas early studies on plastic pollution mostly focused on the impacts of meso- and macroplastics on living organisms, highlighting issues such as the entanglement of birds and aquatic mammals in plastic nets and ropes [3], as well as the ingestion of plastic materials by both aquatic and terrestrial animals [4]-[6]. Over time, it became increasingly evident that humans are extensively exposed to MPs in everyday life, including to MPs from cosmetics

[7] and plastic kitchenware [8] and of course to MPs in the natural environment. Microplastics have been detected throughout the food chain [9] and in a wide range of human tissues and organs, including the placenta [10] [11], heart [12], and brain [13] [14], among others. Also, MPs have been found in blood [15] and the lymphatic system [16]. Although the current understanding of the toxicity and biological impacts of microplastics remains limited, MPs have been linked to chronic inflammation [17], immune dysregulation [18], cardiovascular disease [19], respiratory effects [20] and metabolic disorders [21]. These concerns have made research into the occurrence, sources, sinks, and environmental transport of microplastics in the natural environment an urgent scientific priority. Nevertheless, scientific research on microplastics has developed unevenly across different regions of the world. Among the earliest reports from Africa on small plastic debris in the environment were those by Ryan *et al.* [22]-[24] which included observations of plastic nurdles. Over the past decade, research on and reporting of MPs in the African environment have increased substantially, with studies from the continent now accounting for a significant share of the global literature, with a considerable proportion of these studies originating from South Africa.

Between 1990 and 2017, 33 African countries, representing a combined population of more than 856 million and for which data spanning at least 10 years were available, imported approximately 86.14 Mt of primary polymers and 31.5 Mt of plastic products. Extrapolation to the continental scale (54 countries with a population of 1.216 billion) suggests that Africa imported approximately 172 Mt of polymers and plastic products, valued at approximately \$285 billion, during this period. When plastics contained in manufactured goods are also considered, the total plastic input is estimated to have reached 230 Mt. The largest shares were imported by Egypt (43 Mt; 18.7%), Nigeria (39 Mt; 17.0%), South Africa (27 Mt; 11.7%), Algeria (26 Mt; 11.3%), Morocco (22 Mt; 9.6%), and Tunisia (16 Mt; 7.0%). In addition, primary plastic production in eight African countries contributed a further 15 Mt between 2009 and 2015. These numbers have been on the increase. Thus, in 2024, 6.8 Mt of polythene were produced in Africa, mostly in Algeria, Morocco, Egypt, Nigeria and South Africa. Recent market analyses also indicate rapid growth in Nigeria's PE production capacity. In addition, 3.6 Mt polypropylene, 0.96 Mt polyvinyl chloride (PVC), 0.59 Mt polyethylene terephthalate (PET), and 0.21 Mt polystyrene (PS) [25].

Packaging represents the largest market segment for polymers and plastics in Africa, driven by increasing demand from the food, beverage, pharmaceutical, and e-commerce sectors. Polyethylene and polypropylene dominate this market because of their low weight, flexibility, and durability. The continued expansion of online retail and home delivery services has further increased demand for plastic packaging. Although sustainability concerns have stimulated the development of recyclable and biodegradable packaging materials, consumption of packaging plastics in Africa is expected to continue growing, driven by population growth, urbanization, and changing consumer lifestyles.

The accumulation of plastic waste remains a significant challenge across many African countries. It has been estimated that approximately 19 - 25 Mt of plastic per year are generated on the continent [26], based on data for the late 2010s to early 2020s, although some estimates put it as high as 31 Mt. Nigeria, the continent's most populous country and one of its fastest-growing economies, generates approximately 2.5 Mt of plastic waste annually. With a relatively low recycling rate of around 12% [27], a substantial proportion of this waste leaks into the natural environment. It is estimated that about 17 Mt are mismanaged through inadequate collection, open dumping, or uncontrolled disposal. The World Bank projects that waste generation in Sub-Saharan Africa will increase by 197% by 2050, with plastics expected to constitute a considerable share of this growth. Current assessments indicate that environmentally sustainable end-of-life management options for plastic waste, including recycling and energy recovery, remain at an early stage of development in Africa, although recycling initiatives and thermal recovery projects have begun to emerge in several countries.

Synthetic textiles are a case in point as they represent a notable example of the broader waste management challenge in Africa. The continent is a major destination for used clothing from Europe and other regions, with several countries receiving large quantities of second-hand garments each year. However, a significant proportion of these imports eventually becomes waste due to poor quality, damage, or insufficient market demand. For example, Ghana receives approximately 0.225 Mt of second-hand clothing annually, and studies indicate that around 40% - 50% of imported garments may be unsuitable for resale and subsequently enter waste streams. Overall, Africa is estimated to receive approximately 1.0 - 1.1 Mt of second-hand clothing and textiles each year. In addition, African countries import approximately 1 - 3 Mt of new textiles and garments annually, while domestic production contributes an estimated 0.4 - 0.8 Mt of synthetic textiles per year.

Considering all textile waste generated in Africa, including locally discarded clothing and imported second-hand garments that have reached the end of their usable life, current estimates suggest a volume well above 0.5 Mt annually, potentially reaching 1 Mt or more. Synthetic fibres are expected to represent approximately 50% - 70% of textile materials in many African clothing markets, particularly within imported second-hand clothing streams, while the remaining share consists mainly of natural fibres. Consequently, a substantial proportion of discarded textiles contains synthetic polymers that are persistent in the environment.

Most textile waste in Africa is currently disposed of in landfills, uncontrolled dumpsites, or through informal waste management practices. Nevertheless, initiatives aimed at textile recycling and reuse are beginning to emerge, including the incorporation of waste fibres into construction materials [28] and other applications. However, caution is required, as recycled textile fibres containing synthetic polymers may still contribute to microplastic pollution through the release of microfibrils during processing, use, or degradation. It will be evident from the cur-

rent review that microfibers make up a substantial portion of the microplastics found in African freshwaters, including in river sediments.

Plastics discarded in landfills and at undesignated sites are among the most significant sources of MPs in the environment [29] as the fragmentation and weathering of improperly managed plastic waste result in the continuous release of MPs into surrounding terrestrial and aquatic ecosystems, where they are widely dispersed. Transport of MPs from the terrestrial to the aquatic environment is well recognized, where many MPs ultimately move into the oceans [30]-[35]. This article is to provide a comprehensive review of research on the occurrence, distribution, and environmental fate of microplastics in African freshwater environments and is seen as part 1 of a three part review on microplastics in the African aquatic environment.

2. Methodology

The databases Scopus®, Scifinder® and Web of Science® were used for this review. The literature search was last conducted on August 7, 2026. Typical keyword combinations used were “Africa” AND “microplastic”, “Africa” AND “plastic”, “Africa” AND “microplastic” AND “river”, “Africa” AND “microplastic” AND “sediments”, “Africa” AND “plastic” AND “lake”, “Africa” AND “plastic” AND “pollution”, and “Africa” AND “microplastic” AND “pollution”. In addition, combinations that included the name of African countries AND microplastic were looked for, also. Typical examples of such combinations are “South Africa” AND “microplastic”, “Nigeria” AND “microplastic”, and “Egypt” AND “microplastic”, which gave 143 entries, 71 entries, and 54 entries, respectively, in Scopus®. The publications identified through these database searches were examined carefully to determine their relevance to the scope of this review, where it must be noted that many of the initially returned publications were focused on microplastics in the African marine environment, which is not the topic of the review. Ultimately, the number of entries utilized for this review decreased significantly to 39 (South Africa), 16 (Nigeria), and 6 (Egypt). Publications by governmental organizations, Intergovernmental Organizations (IGOs) and or Nongovernmental Organizations (NGOs), which are often not abstracted by the databases named above, were searched for on the world-wide-web, utilizing the search words above. The language of publication was not an eligibility criterion; however, all but one of the included publications were in English, with the exception being a publication in French. Abstracts of all entries were examined. When the abstract indicated that a quantitative analysis of microplastic in an African freshwater system, the publication was accessed through the UAEU University library, if not publicly available. All pertinent references in the given papers were analyzed for any missed publications. The “forward” citations given in the databases for the entries found in the databases were also examined for any missed publications. This review considers studies that quantitatively assessed microplastic contamination in African freshwater environments, together with investigations of potential microplastic

sources to these environments, including wastewater treatment plants. Near their outlets, rivers may exhibit brackish conditions. For the most part, this review excludes data from brackish waters. However, exceptions are made when two closely situated riverine systems are compared and one of the systems is brackish. No paper was discarded on the basis of the actual data presented. Where data seemed to be in conflict with other published data, the conflict was stated in the review without evaluation of the actual data. Data on MPs in biota have largely been excluded, as they will be addressed in a separate review.

3. Note on the MP Extraction Procedures and Identification Used in the Reviewed Research

To date, no standardized protocol exists for sampling microplastics (MPs) from aquatic environments, resulting in considerable methodological variability across studies [36]. This is also reflected in the reviewed studies from the African region. From rivers, surface water MPs are most commonly collected using buckets or similar containers. In studies on MP presence in lakes, especially in the East African Great lakes, Neuston or manta nets, which differ in mesh size and dimensions, can be used. In open-water environments these nets are typically towed at varying speeds and durations, although the procedures used to transfer the collected material into storage containers are often poorly described. Alternatively, also here, water samples may be collected directly using metal buckets or sampling canisters. Direct water sampling methods often result in the detection of higher MP concentrations than net-based sampling approaches.

Sometimes, following collection, water samples are filtered on-site through metal sieves of different mesh size. Occasionally, the water samples are subjected to oxidative digestion using hydrogen peroxide (H_2O_2) or alkaline digestion with aqueous potassium hydroxide (KOH) to remove organic matter prior to the final filtration procedure. Filtration is commonly performed using metal sieves and membrane or paper filters, where cellulose acetate or cellulose nitrate filters are often used.

Sediment samples are typically collected using metal scoops or corers. The samples may first be sieved to remove coarse material before undergoing density separation using high-density salt solutions, including saturated sodium chloride (NaCl), sodium iodide (NaI), or zinc chloride (ZnCl_2). The density of the salt solution used can have an influence on the amounts of MPs detected, as MPs of higher density often only become buoyant in highly dense separation fluids. The supernatant containing buoyant microplastics is subsequently filtered. To further eliminate residual organic material, the recovered particles are often subjected to a second digestion step using H_2O_2 , KOH, or Fenton's reagent. The remaining material is then filtered, dried, and prepared for subsequent identification and characterization of microplastics. The sampling and processing methods used for MP analysis in the individual studies are summarized in **Table 1** and **Table 2**.

Table 1. Published studies on MP concentrations in surface waters in African rivers and lakes.

Country	Location	MP concentration	Sampling technique	Separation technique Density gradation separation technique	Digestion	Major polymer types	Co-investigation of living organisms	Reference
Egypt	Nile River, Rosetta branch	500 - 1609 MP/m ³ (761 ± 31 MP/m ³)	phytoplankton net (mesh size 55 µm)	Filtered through nitrocellulose membrane filter (mesh size 0.45 µm)	(−)	PE, PP; PS	(−)	Shabaka <i>et al.</i> , 2022 [37]
Egypt	Nile River, Damietta branch	328 - 4375 MP/m ³ (1718 ± 1008 MP/m ³)						
Egypt	Lake Burullus	165.0 MPs/m ³ (open water) 835.6 MPs/m ³ (near the drains)	Niskin bottle	Filtered through a cellulose nitrate membrane filter (0.45 µm)	10% KOH	LLDPE, PET, PA, PEVA, PTFE	(−)	El-Alfy <i>et al.</i> , 2025 [38]
Egypt	Nile River	2.24 ± 0.6 - 3.76 ± 1.1 MP/L					(+)	Khedre <i>et al.</i> , 2024 [39]
Egypt	Edfu, Nile River	60.6 ± 22.1 MP/L						
	Nagaa Hammadi, Nile River	35.0 ± 39.5 MP/L	1m depth from shallow nearshore areas using bottles	filtered through Whatman Grade 1 filter papers (8 µm pore size)	(−)	ncd	(+)	Hassan <i>et al.</i> , 2026 [40]
	El-Wasta	13.6 ± 9.6 MP/L						
	El Minya	3.0 ± 0.8 MP/L						
Egypt	Sohag City, Nile River	2.52 ± 0.63 MP/L to 6.7 ± 2.0 MP/L	Grab sampler (steel buckets)	Filtered through cellulose nitrate filter paper with 0.45 µm pore size	10% KOH		(+)	Ashry and Al Naggar [41]
Egypt	Manzala Lake	0.82 ± 0.70 MP/m ³	manta trawl (mesh size 300 µm; 55 cm diameter)	(−)* Filtering through 0.63 µm nitrocellulose filter	H ₂ O ₂	PP, PE, PS	(−)	Shabaka <i>et al.</i> , 2026 [42]
Egypt	Edku Lake	0.09 ± 0.06 MP/m ³						
Egypt	Mariout Lake	0.33 ± 0.19 MP/m ³						
Ethiopia	Megech River	0.55 ± 0.31 MP/L	stainless-steel buckets					Nigatu <i>et al.</i> , 2026 [43]
Ghana	Densu delta	83.3 MP/L		Filtration through 1.2 µm Whatman GF/C microfiber filter paper	KOH, 60°C		(+)	Blankson <i>et al.</i> , 2022 [44]
Ghana	Weija dam, Densu river	150 MP/L						
Kenya	Lake Navaisha	0.183 ± 0.017 - 0.633 ± 0.067 P/m ² Mean: 0.407 ± 0.135 P/m ²			H ₂ O ₂	PP, PE, PES	(−)	Migwi <i>et al.</i> , 2020 [45]
Nigeria	Ox-bow Lake, Yenagoa	1004 - 8329 items/m ³ (dry season) 201 - 8369 items/m ³ (rainy season)	Teflon pump, passing surface water through a stainless steel mesh	filtered through a 0.40 µm glass microfiber filter paper (GF/F)	30% H ₂ O ₂	PET (72.6%) PVC (10.9%)	(−)	Oni <i>et al.</i> , 2020 [46]
Nigeria	Ikpoba River	2.67 ± 0.58 - 8.00 ± 1.00 MP/m ³				PS, PE, PP	(+)	Ogbomida <i>et al.</i> , 2023 [47]
Nigeria	Major rivers in southwestern Nigeria	6.71 - 17.12 P/L (dry season) 12.41 - 22.73 P/L (wet season)				PP, PE	(−)	Ololade <i>et al.</i> , 2024 [48]
Nigeria	Benue river, Nigeria	Southern bank: 0 - 11 P/L (dry season); 0 - 9 P/L (rainy season)		NaCl	H ₂ O ₂			Ajegi <i>et al.</i> , 2025 [49]
Nigeria	Osun River, Oshogbo	3791 - 22,079 MP/L	2.5 L amber bottles	Filtered through 0.45 µm cellulose acetate membrane			(+)	Idowu <i>et al.</i> , 2024 [50]

Continued

Nigeria	Kaduna River	153 MPs/L			Wet peroxide oxidation	PP, PE, PS, PVC, PET	(–)	Aliyu <i>et al.</i> , 2023 [51]
Nigeria	Nwangele, Imo State	440 - 1556 MPs/L	NC	Filtered through a 11 µm Whatman cellulose filter		PET (29 %), PE (22 %), PVC (16 %), PP (14 %)	(–)	Ebere <i>et al.</i> , 2019 [52]
Nigeria	Oke Ado, Ona River Basin	60.05 P/L						
Nigeria	Ogunpa Downstream, Ona River Basin	56.22P/0.75 L						
Nigeria	Ogunpa Midstream Ona River Basin	39.18 P/L	HDPE canister	Filtered through 0.45 µm pore size glass fibre filter papers			(–)	Thomas and Egbinola, 2026 [53]
Nigeria	Orogun downstream, Ona River Basin	23.68 P/0.75 L						
Nigeria	five Cowrie Creek (brackish water)	100 - 490 P/L	25 µ m mesh standard conical plankton net	Filtration through cellulose membrane filters with a nominal pore size of 0.45 µm	30% H ₂ O ₂	PA, PET, PE, PP	(+)	Popoola <i>et al.</i> , 2026 [54]
Nigeria	Imakun Omi Ise Creek	100 - 230 P/L				PS > PE > PP > PET		
RSA	Diep River, Western Cape	1.25 - 5.25 P/L (spring, 20 µm) 1.6 - 3.3 P/L (autumn, 20 µm) 2.15 - 3.8 P/L (winter, 20 µm)	metal bucket, then sieved on site (250 µm stainless steel sieve)	Filtered through 20 µm mesh filter		PE > PS > PP, PVC, NL, PiB, Cotton (as a sum with sediments)	(–)	Khan <i>et al.</i> , 2025 [55]
RSA	Nyl/Mogalakwena rivers, Limpopo	16.7 ± 25.82 P/m ³ - 450 ± 132 P/m ³ (mean 160 ± 197 P/m ³)	20L steel bucket		KOH	nc	(–)	Dahms and Greenfield, 2025 [56]
RSA	Braamfontein Spruit	705 P/m ³	25 L container		10% KOH		(+)	Dahms <i>et al.</i> , 2020 [57]
RSA	4 reservoirs, Vhembe District Municipality, Limpopo	6.07 - 21.77 P/100L (dry season) 7.33 - 19.27 P/100L (wet season)	25 L stainless bucket, then filtered through 63 µm mesh sieve	NaCl, Sieved through 63 µm mesh sieve	30% H ₂ O ₂	PE (61.2%) PP (27%) PS (10.1%) PET (1.7%)	(–)	Mutshewka <i>et al.</i> , 2025 [58]
RSA	Olifants River, Kruger Natl. Park	27 ± 12 MPs/L	Stainless-steel bucket, 25 µm sieve	NaI, though 0.45 µm cellulose filter paper	H ₂ O ₂ , HNO ₃	PET (32%), PVA (14%), PE (12%), PEVA (12%), PP (10%),	(–)	Shikwamban a <i>et al.</i> , 2024 [59]
RSA	Sabie Riber, Kruger Natl. Park	18 ± 13 MPs/L	Stainless steel bucket 25 µm sieve					
RSA	Orange-Vaal River system	0.23 ± 0.27 P/L	Either galvanised steel bucket with filtration through 25 µm nylon mesh filter or neuston net	NaCl, then filtered through 25 µm filter	(–)	NC	(–)	Weideman <i>et al.</i> , 2019, 2020 [60]
RSA	Orange-Vaal River system	1.7 ± 5.1 P/L						[61]
RSA	Vaal River, Johannesburg	0.61 ± 0.57 P/m ³	55 µm plankton net	NaCl, NaI	Fenton reagent	HDPE, LDPE, PP	(–)	Ramaremissa <i>et al.</i> , 2022 [62]
RSA	Upper Vaal River	3300 P/m ³	25 L container	Filtration through 53 µm sieve	10% KOH	N/A	(+)	Dahms <i>et al.</i> , 2022 [63]

Continued

RSA	Plankenburg river, Western Cape	5.13 ± 6.62 MP/L (spring) 1.52 ± 2.54 MP/L (autumn)	metal bucket, filtered through 20 µ m stainless steel sieve	NaCl, filtered with a pump system through 20 µ m mesh	KOH	PE (47.37%), Cotton (44.75%), PP (2.63%), PP (5.25%)	(–)	Apetogbor <i>et al.</i> , 2023 [64]
RSA	uMsunduzi River	39 P/L	agitated to resuspend surface sediments before collection into 1L bottles	NaCl, then filtration through 20 µ m mesh sieve and 1.22 µ m pore size glass fiber filter paper	30% H ₂ O ₂	PE, PP, PS, PVC, PET, nylon, PTFE	(–)	Malambule <i>et al.</i> , 2026 [65]
RSA	Swartskop River	51 P/L						
RSA	Buffalo River	0.3 - 0.9 P/L Mean: 0.60 ± 0.18 P/L (wet season) 0.35 - 0.75 P/L Mean: 0.53 ± 0.13 P/L (dry season)	stainless steel bucket		FeSO ₄ ·7H ₂ O	N/A	(–)	Mvovo <i>et al.</i> , 2025 [66]
Lesotho, RSA, Botswana and Namibia	Orange-Senqu River	1.00 ± 0.7 MP/L to 69.75 ± 68.6 MP/L	steel bucket	gravity filtered through a 25 µ m nylon mesh			(+)	Graham <i>et al.</i> , 2024 [67]
Tanzania	River Themí and its tributaries, Arusha	0.2 - 0.6 items/L (200 - 600 items/m ³)	Up to 5 cm depth	Na ₂ WO ₄ ·2H ₂ O	Fenton's reagent 30% H ₂ O ₂	PE, PS	(–)	Kundu <i>et al.</i> , 2022 [68]
Tunisia	Dam reservoirs	10.5 - 12.38 items/L (10.5 × 10 ³ - 12.38 × 10 ³ P/m ³)				PE (67%), PP (33%)	(–)	Toumi <i>et al.</i> , 2025 [69]
Uganda	Nakivubo catchment	1569 ± 1474 P/m ³ (dry season) 2140 ± 3670 P/m ³ (wet season)	20 L stainless steel bucket	NaCl, filtration through 32-µ m sieve,	Fenton reagent	PE, PE-PP co-polymers	(–)	Ocakacon <i>et al.</i> , 2025 [70]

*in this case, (–) means no gradient density separation has been reported.

Table 2. Published studies on MP concentrations in sediments of African rivers and lakes.

Country	Location	MP concentration	Sampling technique	Separation technique Density gradation separation technique	Digestion	Major polymer types	Co-investigation of living organisms	Reference
Tunisia	Jedara stream	6920 ± 395.98 MP/ kgdw	Stainless steel spoon	NaCl	(–)		(–)	Toumi <i>et al.</i> , 2019 [71]
Tunisia	Khima stream	2340 ± 227.15 MP/kgdw	(5 cm sampling depth)					
Egypt	Nile River, Rosetta branch	10 - 530 MP/kgdw (167 ± 137 MP/kgdw)		NaCl, filtration through a nitrocellulose membrane filter of mesh size 0.45 µ m		Main: PE, PP, PA, PET Minor: PEVA, PTFE	(–)	Shabaka <i>et al.</i> , 2022 [37]
Egypt	Nile River, Burullus branch	300 - 3045 MP/kgdw (1630 ± 1303.78 MP/kgDW)	Van Veen grab		(–)			
Egypt	Nile River, Damietta branch	250 - 1310 MP/kgdw (593 ± 35 MP/kgdw)						
Egypt	Nile River	381 ± 113 MP/kgdw 298 ± 63 - 520 ± 80 MP/kgdw	Stainless steel spoon	NaCl, NaI	H ₂ O ₂		Aquatic insects	Khedre <i>et al.</i> , 2024 [39]
Egypt	Edfu, Nile River	162.3 ± 75.5 MP/kgdw						
Egypt	Nagaa Hammadi, Nile River	143.3 ± 20.9 MP/kgdw	Van Veen grab sampler	Sieved through mesh with 2 mm to 63 µ m apertures	(–)	ncd	(+)	Hassan <i>et al.</i> , 2026 [40]
	El-Wasta	142.6 ± 134.3 MP/kgdw						
	El Minya	82.6 ± 39.3 MP/kgdw						

Continued

Ethiopia	Lake Hawassa	11 - 74 MP/m ³	Up to 3 cm depth	NaCl, ZnCl ₂	H ₂ O ₂	PES (82%), PE (15%), PS (3%) (overall)	(-)	Jeevanandam <i>et al.</i> , 2022 [72]
Ethiopia	Lake Ziway	764 (0.05 - 36,233) mg/kgdw	Ekman grab (up to 2 cm depth)	NaCl	10% KOH		(+)	Merga <i>et al.</i> , 2020 [73]
Ethiopia	Megech River	0.55 ± 0.31 MP/L	stainless-steel shovel	NaCl Filtration through Whatman Grade 40 filter	Fenton reagent		(-)	Nigatu <i>et al.</i> , 2026 [43]
Ghana	Densu delta	375 MP/kgdw	N/A				(+)	Blankson <i>et al.</i> , 2022 [44]
Ghana	Weija dam, Dansu river	400 MP/kgdw	N/A	NaCl	10% KOH		(+)	
Ghana	Volta lake	3 - 28 MP /50 gdw (mean: 13.3 MP/50 gdw)	Ekman grab	ZnCl ₂ , filtration through 1.5 µm glass membrane filter	H ₂ O ₂	PE (22%), PP (20%), PA (20%), PES (15%), PVC (13%), PS (10%)	(+)	Boateng <i>et al.</i> , 2024 [74]
Lesotho, RSA, Botswana and Namibia	Orange-Senqu River	0 - 4000 P/kgdw (825 ± 1493 P/kgdw)	metal spoon (up to 5 cm depth)	ZnCl ₂ Centrifugation and Filtration through 0.2 µm porosity Whatman Anodisc	H ₂ O ₂		(+)	Graham <i>et al.</i> , 2024 [67]
Namibia	Ishana system	3.8 - 9.8 P/kgdw						
Namibia	Kunene	1.8 P/kgdw						
Namibia	Oranje	1.6 P/kgdw						
Namibia	Avis River	14.4 P/kgdw	Wood shovels & spoons	NaCl	(-)	PE, PP	(-)	Faulstich <i>et al.</i> [75]
Namibia	Kuiseb	20.3 P/kgdw						
Namibia	Olifantes	38.8 P/kgdw						
Namibia	Owamb0	65.9 P/kgdw						
Nigeria	Ikpoba River	1.33 ± 0.58 - 12.67 ± 6.66 MP/kgdw	Van Veen grab (up to 10 cm depth)	NaCl, NaI	30% H ₂ O ₂	PET, PVC	(+)	Ogbomida <i>et al.</i> , 2023 [47]
Nigeria	Osun River, Oshogbo	392 - 1590 MP/kgdw	Van-Veen grab sampler	ZnCl ₂ filtration through 0.45 µm membrane	H ₂ O ₂		(+)	Idowu <i>et al.</i> , 2024 [50]
Nigeria	River Benue	Southern bank, surface: 2.8 ± 1.9 P/kgdw Southern bank, deeper layers: 0.8 ± 1.0 P/kgdw Northern bank, surface: 1.9 ± 2.6 P/kgdw Northern bank, deeper layers: 0.3 ± 0.58P/kgdw		NaCl, NaI	H ₂ O ₂	PS, PET, PA	(-)	Ajegi <i>et al.</i> , 2026 [49]
Nigeria	five Cowrie Creek (brackish water)	70 - 220 MP/kgdw	Van Veen grab sampler	NaCl, filtration through a 0.45 µm cellulose membrane	10% KOH	PP, ABS, PE, PET	(+)	Popoola <i>et al.</i> , 2026 [54]
Nigeria	Imakun Omi Ise Creek	100 to 210 MP/kgdw				PS >PP = PET >PE		

Continued

RSA	Olifants River, Kruger Natl. Park	2682 ± 2393 MPs/kgdw	Stainless steel hand trowel (up to 5 cm depth)	NaI, then filtration through metal sieves (300 µm, 150 µm, 100 µm, 75 µm, and 25 µm), finally through 0.45 µm cellulose filter paper	H ₂ O ₂ , HNO ₃	PET (39%), PE (15%), PP (11%), PVC (8%)	(–)	Shikwambana <i>et al.</i> , 2024 [59]
RSA	Sabie River, Kruger Natl. Park	1139 ± 570 MPs/kgdw						
RSA	Vaal River, Johannesburg	4.6 × 10 ² ± 2.8 × 10 ² P/kgdw	Van Veen grab	NaCl, NaI	10% KOH	HDPE, LDPE, PP	(–)	Ramaremissa <i>et al.</i> , 2022 [62]
RSA	Upper Vaal River	46.7 P/kgdw	to ≈ 10 cm depth	NaCl, then filtered through 53 µm sieve	FeSO ₄ ·7H ₂ O		(+)	Dahms <i>et al.</i> , 2022 [63]
RSA	Buffalo River	7 - 23 P/kgdw Avg.: 20.73 ± 6.54 P/kgdw (dry winter season) 14 - 32 P/kgdw Avg.: 14.87 ± 4.85 P/kgdw (hot summer season)	stainless steel scoop	sodium hexametaphosphate (NaPO ₃)	Fe ₂ SO ₄ ·7H ₂ O	PP, PE, PET, PS	(–)	Mvovo <i>et al.</i> , 2025 [66]
RSA	Diep River, Western Cape	180 - 340 MP/kg (autumn) 130 - 450 MP/kg (spring) 210 MP/kg (summer) 110 - 170 MP/kg (winter)	Metal scoop	NaCl, filtered through a 20 µm nylon mesh sieve	KOH	PE > PS > PP, PVC, NL, PiB, Cotton (as a sum with surface water)	(–)	Khan <i>et al.</i> , 2025 [55]
RSA	Vaal River	463.28 ± 284.08 P/kgdw	Van Veen grab (up to 10 cm depth)	NaI, filtration through GF/A Whatman filter paper (1.6 µm pore size)	KOH	HDPE, LDPE, PES, PU, PEH, with PEVA, PE, PP the most common	(–)	Saad <i>et al.</i> [2022] [76]
RSA	Plankenburg river, Western Cape	1587.50 ± 599.32 MP/kgdw	Metal scoop (up to 5 cm depth)	NaCl	10% KOH	PE (65.79%), Cotton (18.57%), PP (9.74%), PET (5.90%)	(–)	Apetogbor <i>et al.</i> , 2023 [64]
RSA	River catchments along the South Africa's coastline	0 - 567 fibres/dm ³	up to 5 cm depth	NaCl, filtered through 40 µm sieve	(–)	mostly microfibers	(–)	
RSA	Knysna estuary	4 fibres/dm ³						de Villiers, 2019 [77]
RSA	Swartkops, Eastern Cape	60 fibres/dm ³						
RSA	Mkomaas, Kwa-Zulu Natal	208 fibres/dm ³						
RSA	Mvudi river	76.0 ± 10.0 - 285.5 ± 44.5 MP/kg (hot-wet season) 16.5 ± 4.5 - 27.0 ± 5.0 MP/kg (cool-dry season) 13.0 ± 4.0 - 29.0 ± 10.0 MP/kg (hot-dry season)	up to 5 cm depth	NaCl, then filtered through 63-µm mesh sieve	(–)	N/A	(–)	Dalu <i>et al.</i> , 2021 [78]

Continued

RSA	4 reservoirs, Vhembe District Municipality, Limpopo	84.74 - 374.76 MP/kgdw (dry season) 68.72 - 260.87 MP/kgdw (wet season)	steel hand shovel	NaCl Filtration through 63 µm mesh sieve.	30% H ₂ O ₂ Filtration through 63 µm mesh sieve.	PE (47.3%) PP (27.2%) PS (12.2%) PET (6%) PDMS (5.7%) HDPE (1.6%)	(-)	Mutshekwa <i>et al.</i> , 2025 [58]
RSA	Nyl/Mogalakwen a rivers, Limpopo	13.3 ± 24.2 P/kgdw - 53.3 ± 23 P/kgdw	Steel spade (up to 15 cm depth)	ZnCl ₂ , filtered through Whatman Grade 4 (20 µm) filter paper	10% KOH		(-)	Dahms and Greenfield, 2025 [56]
RSA	Braamfontein Spruit	166.8 P/kgdw	up to 10 cm depth	NaCl filtered through stainless-steel sieves (4000 and 53 µm)			(+)	Dahms <i>et al.</i> , 2020 [57]
Botswana	Okavango Panhandle in Northern Botswana	56.7 - 1756.3 P/kgdw	(up to 15 cm depth)	ZnCl ₂ Filtration over 64 µm sieve and Whatman GF/D glass fibre disk	Fenton reagent	PET, PP, PE, PVC, PS	(-)	Kelleher <i>et al.</i> , 2023 [79]
Tanzania	Urban shores around Lake Tanganyika	24.00 ± 2.88 - 312.67 ± 71.30 P/kg				PE, PP	(-)	Mayoma <i>et al.</i> , 2020 [80]
Nigeria	Ox-bow Lake, Yenagoa	347 - 4031 MP/kgdw (dry season)	Van Veen grab (5 cm depth)	NaI	20% H ₂ O ₂	PET (77.4%) PVC (11.3%)	(-)	Oni <i>et al.</i> , 2020 [46]
Uganda	northern Lake Victoria (beaches near fish landing places)-	75.2 ± 50.0 P/kgdw (microplastics) 16.7 ± 8.1 P/kgdw (mesoplastics) 18.1 ± 4.6 P/kgdw (macroplastics)	Stainless steel trowel, Ponar grab (up to 10 cm depth)	NaCl	H ₂ O ₂ , FeSO ₄ · 7H ₂ O (Fenton reagent)			
Uganda	northern Lake Victoria (recreational beaches)-	1.5 ± 0.6 P/kgdw (microplastics) 3.1 ± 3.1 P/kgdw (mesoplastics) 3.8 ± 3.8 P/kgdw (macroplastics)	Stainless steel trowel, Ponar grab (up to 10 cm depth)	NaCl	H ₂ O ₂ , FeSO ₄ · 7H ₂ O (Fenton reagent)	Overall: PE (54.2%), PP (23.3%), PET (4.2%), PVC (11.7%) PA (2.5%)	(-)	Egessa <i>et al.</i> , 2020 [81]
Uganda	northern Lake Victoria (lake sediment)-	9.5 ± 2.6 P/kgdw (microplastics) 2.1 ± 1.5 P/kgdw (mesoplastics) 7.7 ± 4.5 P/kgdw (macroplastics)	Stainless steel trowel, Ponar grab (up to 10 cm depth)	NaCl	H ₂ O ₂ , FeSO ₄ · 7H ₂ O (Fenton reagent)			

*sum of all litter items.

MP contamination is most commonly reported as the number of MPs per kilogram of dry sediment (MP/kg dw), although some studies use other sediment masses, such as per gram or per 50 g. These values can be readily converted to MP/kg dw. Less commonly, and less easy to evaluate by the reader, MP abundance is expressed per unit volume of sediment (e.g., MPs per 500 mL of sediment), or per unit area of the sampled sediment. In the latter case, the mean sampling depth

is typically reported to indicate the volume of sediment represented by the area-based measurement.

The vast majority of the reviewed papers included a statement on quality control, including the use of blank samples to assess background contamination associated with the experimental setup.

MPs are typically examined under a microscope, while their polymer composition is most commonly identified using μ -FTIR spectroscopy. Raman spectroscopy and pyrolysis-GC-MS are used less frequently for polymer identification.

4. Overview on MP Contamination in African Freshwater Environments

Microplastic (MP) contamination of African freshwater environments has received increasing scientific attention over the past decade, which has led to a number of reviews on the situation of plastic waste management in Africa [82]-[84], on policies and regulations on single use plastics [85]-[87], on plastics and MPs in the African environment [88]-[101], specifically the aquatic environment [88] [89] [91] [95] [97]-[100], including the freshwater environment [97]-[100]. Also, regional reviews on MPs in the African aquatic environment have been published (Egypt [102], Morocco [103], Tanzania [104], Nigeria [105] [106], Ghana [107] South Africa [108]-[111]) as have papers on the contamination in specific locations in Africa such as the Eastern Great Lakes [112]. However, compared with other regions of the world, freshwater MP research across Africa remains geographically uneven, with most investigations concentrated in a limited number of countries, including South Africa, Nigeria, Ghana, Uganda, Egypt, Tunisia, Botswana and Namibia. Many African freshwater systems remain poorly characterized, particularly in Central Africa and parts of North and West Africa. Nevertheless, available studies demonstrate that MPs are widespread across the continent, occurring in rivers, lakes, reservoirs, wetlands and estuarine transition zones.

African freshwater systems are particularly vulnerable to plastic contamination due to rapid population growth, increasing urbanization, expanding industrial and agricultural activities, inadequate solid waste management infrastructure and variable wastewater treatment capacity. Rivers act as major transport pathways, transferring plastic waste from terrestrial environments into downstream lakes, reservoirs, estuaries and coastal waters [113]. In densely populated catchments, wastewater treatment plants (WWTPs) [114] [115], stormwater runoff [76] and industrial discharges are frequently identified as important sources of MPs. However, studies from more rural and remote environments also demonstrate that MPs can reach freshwater ecosystems through diffuse pathways, including atmospheric deposition [116], agricultural activities [68] [117], shoreline use and community practices associated with direct reliance on rivers for domestic activities. It has been noted by Stokal *et al.* [30], however, that the transport of plastic by African rivers into the oceans is mostly the transport of macroplastics (97% of the total mass) rather than microplastics (3% of the total mass). Stokal *et al.* [30]

attribute the microplastics transported by the major African rivers to mismanaged plastic waste (15%), representing secondary microplastics from diffuse sources, and to sewage inputs as point sources, comprising laundry (45%), car tyres (7%), personal care products (3%), and household dust (30%). According to their model, Schmidt *et al.* [34] place the Nile River (Egypt) and the Niger River (Nigeria) among the top ten rivers worldwide in regard to the release of plastic wastes into the marine environment. It should be noted that Lebreton *et al.* [32], using an amended model, identify three other African rivers—the Kwa Ibo (Qua Iboe, Nigeria), Cross (Nigeria/Cameroon), and Imo (Nigeria)—among the 20 rivers worldwide that contribute the highest annual plastic loads to the oceans. Using a third modeling approach, Meijer *et al.* in 2021 [33] likewise identify Nigeria and Cameroon among the 20 countries contributing the largest amounts of plastic waste to the oceans. They are joined by Tanzania, with the Msimbazi River being the largest contributor of plastic emission to the ocean of all Tanzanian rivers [33].

Reported MP concentrations vary considerably among African freshwater systems, reflecting differences in environmental conditions, pollution pressures, sampling methodologies, particle size ranges analyzed and reporting units. Sediments generally contain higher MP abundances than surface waters, because they act as important sinks for denser particles and particles that become incorporated into depositional environments. However, hydrological conditions strongly influence the distribution and mobility of MPs, with high-flow events, seasonal flooding and rainfall-driven runoff contributing to the mobilization and downstream transport of particles. Conversely, periods of low flow may promote sedimentation and local accumulation.

A consistent pattern across African freshwater studies is the dominance of microfibrils, which are frequently the most abundant particle morphology reported. Fibrils are commonly associated with domestic wastewater, textile washing, fishing activities and incomplete removal during wastewater treatment processes. Fragments are the second most frequently reported morphology and are generally attributed to the breakdown of larger plastic items. Other particle forms, including films, beads and foams, occur locally depending on catchment characteristics and dominant pollution sources.

Polyethylene (PE) and polypropylene (PP) are the most frequently identified polymers in African freshwater environments, reflecting their extensive use in packaging, household products and consumer materials. Other commonly reported polymers include polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), polyamide (PA/nylon), polyester (PES) and polyurethane (PU). Polymer composition often provides an indication of dominant local sources, with PET and fibrils frequently linked to textile-related inputs, while PE, PP and PS are associated with packaging and household plastic waste.

Anthropogenic pressures are strongly reflected in spatial patterns of MP contamination. Higher concentrations are commonly observed downstream of urban centers, wastewater discharge points, industrial areas, agricultural zones and

densely populated settlements. Several studies have demonstrated clear relationships between MP abundance and land-use characteristics, including population density, built infrastructure and catchment modification. Conversely, research from protected or less densely populated areas, such as sections of the Kruger National Park and the Okavango system, demonstrates that freshwater ecosystems distant from major urban centers are still affected by transported MPs originating elsewhere within their catchments.

Seasonality represents an important factor controlling MP transport in African freshwater systems. In tropical and subtropical regions characterized by distinct wet and dry seasons, increased rainfall often enhances MP mobilization through surface runoff, erosion and increased river discharge. Several studies have reported higher MP concentrations in surface waters during wet seasons, reflecting increased transport from terrestrial sources. However, some systems show higher sediment concentrations during dry periods due to reduced dilution, lower flow velocities and enhanced particle deposition. These contrasting patterns demonstrate that seasonal effects are strongly dependent on local hydrology, catchment characteristics and the environmental compartment investigated.

Although research has expanded considerably, comparisons among studies remain challenging due to differences in sampling strategies, analytical techniques, size detection limits and reporting approaches. Many studies investigate only a single environmental compartment, such as surface water or sediment, limiting understanding of MP exchange processes between these compartments. Furthermore, information regarding long-term trends, ecological impacts, biological uptake and the effectiveness of mitigation strategies remains limited for many African freshwater systems. Those studies that combine investigations into MP contamination in sediment and/or water samples with an assessment of MP uptake in biota are marked with (+) in **Table 1** and **Table 2**, those that do not with (–).

Overall, current evidence indicates that MP contamination is widespread throughout African freshwater environments. The distribution and accumulation of MPs are controlled by the interaction between anthropogenic sources, wastewater inputs, catchment land use, seasonal hydrology and physical characteristics of freshwater habitats. Understanding these interacting factors is essential for developing effective management strategies aimed at reducing plastic inputs and protecting Africa's freshwater resources.

5. MP Studies in Freshwater Systems According to African Region

5.1. North Africa

Freshwater microplastic (MP) research in North Africa has primarily focused on major river systems, coastal-connected lakes and managed freshwater reservoirs. Despite the importance of these water resources for drinking water supply, agriculture, fisheries and ecosystem functioning, MP contamination remains relatively understudied compared with other regions. Available studies indicate that

North African freshwater systems are increasingly affected by plastic pollution, particularly in densely populated catchments where urbanization, wastewater discharge, industrial activity and inadequate waste management contribute to MP inputs. The River Nile and associated lakes represent the most extensively investigated freshwater environments in the region, while recent studies from Tunisia have highlighted the role of reservoirs and small tributaries as important accumulation zones.

5.1.1. River Nile, Egypt

The River Nile is one of the world's most important freshwater systems and represents a major pathway for the transport of land-based plastic pollution to the eastern Mediterranean basin. Due to the substantial quantities of plastic waste entering the river system, the Nile has been referred to as the "Plastic Nile". The name "Plastic Nile" comes from a documentary, released on Sky in 2020. It was directed and produced by Toby Scunthorpe and presented by Alex Crawford, a Sky News' Special Correspondent. It follows Crawford's investigation along the Nile River, from Lake Victoria to the Mediterranean, examining how plastic pollution affects the river's ecosystems, wildlife, and the millions of people who depend on it. Nevertheless, despite its ecological, social and economic importance, field-based investigations of MP contamination within the Nile system have historically been limited. Recent studies have begun to address this knowledge gap by assessing MP occurrence and distribution along different sections of the river and in connected aquatic environments. Notwithstanding the above, it should be noted that the Nile River appears only in the ranking of Schmidt *et al.* [34] among the ten rivers transporting the largest amounts of plastic to the sea, whereas it is absent from the top 100 most polluting rivers identified by Meijer *et al.* [33], the rankings reported by Lebreton *et al.* [32], and the list of the 50 most polluting rivers published by Plastic Bank [35].

Shabaka *et al.* [37] conducted one of the first comprehensive field investigations of MP contamination in the lower reaches of the Nile system, focusing on the Rosetta and Damietta branches of the Nile Delta and the inlet region of Lake Burullus. Sampling campaigns were conducted during 2021, including approximately 30 km of the Rosetta branch, 23 km of the Damietta branch during high-water conditions, and 10 km near the Lake Burullus inlet. MPs were detected in both surface water and sediments at all investigated locations. Surface water concentrations ranged from 761 ± 319 to 1718 ± 1008 particles m^{-3} , while sediment concentrations varied between 167 ± 137 and 1630 ± 1303 particles kg^{-1} dry weight. The study demonstrated that the lower Nile is significantly impacted by MP contamination and confirmed the role of the river as an important transport pathway for plastic particles entering the Mediterranean Sea. The same group investigated further the spatial variation of microplastics in Lake Burullus in order to analyze the impact of non-point pollution sources on their distribution and fate. The results showed that the average concentration of MPs in the open water was significantly lower (165.0 MPs/m^3) than that near the drains (835.6 MPs/m^3)

[38].

In a separate investigation, Shabaka *et al.* [42] assessed MP contamination in surface waters of three northern Egyptian lakes associated with Nile-derived inputs: Lake Manzala and Lake Edku, which are connected to the Mediterranean Sea, and the inland Lake Mariout. Surface water samples were collected using a 300 µm manta trawl, and MPs were quantified and characterized according to particle morphology and polymer composition. Mean MP concentrations differed among the lakes, with 0.82 ± 0.70 particles m^{-3} recorded in Manzala Lake, 0.09 ± 0.06 particles m^{-3} in Edku Lake and 0.33 ± 0.19 particles m^{-3} in Mariout Lake. MP concentrations in the surface waters of the three northern Egyptian lakes—Manzala, Edku, and Mariout—showed significant variability among sampling sites, which was confirmed by a Kruskal-Wallis test ($H(2) = 6.49$, $p = 0.039$). Transparent films represented the dominant particle type in Manzala (46.10%) and Mariout (36.35%), whereas red fibres dominated in Edku Lake (69.19%). Polypropylene (PP), polystyrene (PS) and polyethylene (PE) were the predominant polymers identified. These findings demonstrate that Nile-connected aquatic systems, including coastal and inland lakes, act as important environments for MP accumulation and redistribution.

In 2024, Khedre *et al.* [39] further investigated MP contamination in the middle section of the Nile Valley by examining surface water and sediments at four locations within Sohag City, Upper Egypt. MPs were detected at all sampling sites, with concentrations ranging from 2.24 ± 0.60 to 3.76 ± 1.10 particles L^{-1} in surface water and from 298 ± 63 to 520 ± 80 particles kg^{-1} dry weight in sediments. The study confirmed that MP contamination extends beyond the Nile Delta and occurs throughout inland sections of the river. Together, these studies indicate that MPs are widely distributed throughout the Nile system, from upstream river reaches through the delta and into connected lake environments, reflecting the influence of extensive anthropogenic activities along the river corridor.

In a subsequent investigation, the same research group [41] reported a further increase in MP contamination in the surface waters of the Nile within Sohag City, with mean concentrations reaching 4.5 particles L^{-1} . By comparing urban and predominantly agricultural sections of the Upper Nile, the authors demonstrated that land use exerted a strong influence on MP abundance. Urban reaches contained significantly higher MP concentrations (6.7 ± 2.0 particles L^{-1}) than areas dominated by agricultural activities (2.52 ± 0.63 particles L^{-1}). These findings reinforce earlier observations that urbanization is a major driver of MP pollution in the Nile and suggest that increasing population density, wastewater discharges and other urban activities contribute more substantially to MP inputs than agricultural land use alone. Here, fibers (75%) dominated with PET (79%) being the most common polymer type.

Hassan *et al.* [40] investigated MP contamination in surface waters and sediments of the Nile River at four locations in Upper Egypt during the winter of 2024. Sampling sites represented different land-use settings, including two urban cen-

tres (Nagaa Hammadi and El Minya City), a rural location (El-Wasta) and the tourist centre of Edfu. MP concentrations in surface water varied considerably among sites, with the highest concentrations recorded at Edfu (60.6 ± 22.1 particles L^{-1}), followed by Nagaa Hammadi (35.0 ± 39.5 particles L^{-1}), El-Wasta (13.6 ± 9.6 particles L^{-1}) and El Minya (3.0 ± 0.8 particles L^{-1}). Sediment concentrations followed a similar spatial pattern, with the highest abundance measured at Edfu (162.3 ± 75.5 particles kg^{-1}), followed by Nagaa Hammadi (143.3 ± 20.9 particles kg^{-1}), El-Wasta (142.6 ± 134.3 particles kg^{-1}) and El Minya (82.6 ± 39.3 particles kg^{-1}). The composition of MPs reflected local anthropogenic activities. Particles collected at Edfu were predominantly associated with paint residues originating from river vessels, whereas MPs at Nagaa Hammadi mainly consisted of fragments derived from plastic sacks and shopping bags. At the rural El-Wasta site, broken plastic cutlery and food packaging were identified as the principal sources. These findings illustrate how local land use and human activities strongly influence both the abundance and composition of MPs within the Nile River and demonstrate that point-specific activities can produce distinct contamination signatures in both the water column and sediments along the same river system.

Hamed *et al.* [118] compared the characteristics of MPs in the Nile River with those reported from adjacent marine environments, including the Mediterranean and Red Seas. They observed that plastics recovered from the Nile exhibited a broader range of fragment sizes and generally showed less surface weathering than particles found in marine environments. In contrast, plastics in the Mediterranean and Red Seas displayed greater surface degradation, which the authors attributed to prolonged exposure to ultraviolet radiation, wave action and other marine weathering processes. The comparatively lower degree of weathering observed in the Nile was linked to the variable hydrological conditions of freshwater systems, where fluctuating flow regimes, sediment transport and repeated burial and re-suspension influence the transport and degradation of plastic particles. These findings highlight that the physical characteristics of MPs are strongly controlled by the receiving environment and demonstrate that freshwater systems such as the Nile can preserve less-weathered plastic particles before they are transported to downstream coastal ecosystems.

5.1.2. Tunisia

Freshwater MP studies in Tunisia have focused mainly on managed reservoir systems and streams draining into coastal lagoons. These investigations highlight the importance of urbanization, wastewater inputs and catchment land use in controlling MP accumulation.

Toumi *et al.* [69] conducted the first assessment of MP contamination in surface waters and sediments of three dam reservoirs in northwestern Tunisia. The study provided important baseline information regarding MP pollution in managed freshwater systems in North Africa. MP concentrations ranged from 10.5 to 12.38 particles L^{-1} in surface waters and from 157.44 to 316.12 particles kg^{-1} dry weight in sediments. Sediment contamination was higher in reservoirs influenced

by urban areas, demonstrating the role of surrounding land use and anthropogenic activity in determining MP accumulation. Polyethylene (PE) was the dominant polymer identified, followed by polypropylene (PP). The authors highlighted that reservoirs can function as important retention zones for MPs and that catchment characteristics strongly influence particle distribution.

In another study, Toumi *et al.* [71] investigated MP concentrations in surface sediments from seven streams draining into the Bizerte Lagoon in northern Tunisia. Considerable spatial variation was observed, with MP abundances ranging from $2\,340 \pm 227.15$ particles kg^{-1} dry weight in the Khima Stream to 6920 ± 395.98 particles kg^{-1} dry weight in the Jedara Stream. The highest MP concentrations occurred in streams located near densely populated areas and those receiving municipal and industrial effluents. All recovered particles were classified as secondary MPs, with fibres representing the dominant morphology. Polyethylene (PE) and polypropylene (PP) were the main polymers identified. The study emphasized the importance of urban runoff, wastewater discharge and industrial activities as major pathways introducing MPs into freshwater systems and subsequently into connected coastal environments.

5.1.3. Regional Synthesis: North Africa

Studies from North Africa demonstrate that MP contamination is widespread across major freshwater systems, particularly in heavily utilized river corridors and water bodies receiving strong anthropogenic pressure. The River Nile acts as a major transport pathway, transferring MPs from inland sources through the delta and into Mediterranean-connected environments. Similarly, Tunisian reservoirs and streams show that urbanization, wastewater discharge and catchment characteristics strongly influence MP accumulation.

Across investigated systems, fibres, PE and PP are consistently dominant, reflecting the importance of domestic wastewater, textile-related sources and plastic packaging waste. The available evidence also highlights the importance of improving wastewater management, strengthening solid waste control and implementing catchment-scale approaches to reduce plastic inputs into freshwater environments. However, significant knowledge gaps remain, particularly regarding long-term trends, seasonal transport processes and ecological impacts of MPs within North African freshwater ecosystems.

5.2. West Africa

West Africa contains some of Africa's most densely populated urban centres and rapidly developing industrial regions, resulting in increasing pressures on freshwater ecosystems from plastic waste generation, wastewater discharge, urban runoff and changing land use. Freshwater microplastic (MP) research in the region has been dominated by studies from Nigeria and Ghana, with investigations focusing mainly on rivers, lakes, reservoirs and wastewater-impacted systems. Available evidence demonstrates widespread MP contamination, with urbanization, inadequate waste management and wastewater inputs consistently identified

as major drivers of pollution. Seasonal hydrological variation also plays an important role, particularly in tropical systems where rainfall can enhance the mobilization and transport of plastic particles.

5.2.1. Nigeria

Nigeria represents one of the most extensively studied countries in Africa regarding freshwater MP contamination. Research has demonstrated the widespread occurrence of MPs in rivers, lakes and urban freshwater systems, with contamination strongly associated with population density, wastewater discharge, industrial activities and catchment modification.

Several studies have highlighted the influence of seasonal variation on MP abundance in Nigerian freshwater systems. Investigations of Oxbow Lake [46] demonstrated that MP concentrations increased during the rainy season, ranging from 507 - 7593 particles kg^{-1} compared with 347 - 4031 particles kg^{-1} during the dry season. The increased abundance during wetter periods was attributed to enhanced runoff, erosion and mobilization of plastic debris from surrounding terrestrial environments. Polyethylene (PE), polypropylene (PP) and polystyrene (PS) were among the dominant polymers identified, although differences in polymer composition between studies indicate variability in local pollution sources.

Wastewater treatment systems have also been recognized as important pathways for MP transport. Aliyu *et al.* [51] investigated MPs in two drinking water treatment plants in Kaduna, Nigeria, which supply water to approximately 1.3 million inhabitants. Raw water entering the treatment plants contained MP concentrations of up to 153 particles L^{-1} , while treated water still contained 25 - 36 particles L^{-1} , which means that the treatment processes reduced MP concentrations by approximately 70%. Thus, conventional treatment processes do not completely eliminate MPs and may represent an important pathway for their continued circulation within freshwater systems. Even, measurable concentrations of 1.4 - 3.7 particles L^{-1} were found in bottled water available in the area.

Ogbomida *et al.* [47] investigated MP contamination in the Ikpoba River, a fourth-order stream located in Edo State, southern Nigeria. The river originates within the rainforest region, flows through sandy areas and passes through Benin City before joining the Ossiomo River, exposing it to substantial urban influences. MPs were detected in all surface water samples collected from three locations: the University of Benin Site, Upper Lawani and Ikpoba Slope. Surface water concentrations ranged from 2.67 ± 0.58 to 8.00 ± 1.00 particles m^{-3} . Fibres represented the dominant particle morphology, accounting for 86.7% of recovered MPs, while polyethylene (PE) and polystyrene (PS) were the most abundant polymers. Sediment concentrations ranged from 40 ± 13.4 to 53.33 ± 18.1 particles kg^{-1} , with polyethylene terephthalate (PET) and PS as the dominant polymers. The prevalence of fibres in both water and sediments suggests that domestic wastewater and textile-related sources contribute substantially to MP contamination in the river.

Ajegi *et al.* [49] assessed MP contamination in sediments of the River Benue, one of Nigeria's largest river systems, by analyzing sediment cores collected from

the northern and southern banks during December 2023. MP abundance was greatest in surface sediments and declined markedly with depth, indicating recent accumulation of plastic particles. On the southern bank, surface sediments contained 2.8 ± 1.9 particles kg^{-1} dry weight with a corresponding plastic mass of 20.3 ± 10.8 mg kg^{-1} dry weight, decreasing to 0.8 ± 1.0 particles kg^{-1} and 3.0 ± 4.3 mg kg^{-1} in deeper sediment layers. A similar pattern was observed on the northern bank, where surface sediments contained 1.9 ± 2.6 particles kg^{-1} and 17.1 ± 20.7 mg kg^{-1} dry weight, declining to 0.3 ± 0.58 particles kg^{-1} and 4.2 ± 9.9 mg kg^{-1} in deeper sediments. Polyamide (PA), polyethylene terephthalate (PET) and polystyrene (PS) were the dominant polymers identified. In a complementary study, the same authors investigated MPs in the surface waters of the River Benue and reported higher MP abundances along the southern bank than along the northern bank [119]. Surface water concentrations ranged from 0 to 11 particles L^{-1} during the dry season and from 0 to 9 particles L^{-1} during the rainy season. The lower concentrations observed during the rainy season were attributed to increased river discharge, which enhanced dilution and promoted downstream transport of MPs. Together, these findings indicate that the River Benue functions both as a depositional environment, preserving a record of recent plastic accumulation within its sediments, and as a dynamic transport pathway in which seasonal hydrological conditions strongly influence the distribution and fate of MPs.

Agbozu *et al.* [120] examined MP contamination in sediments of the River Nun, a major distributary of the Niger Delta in southern Nigeria. Sediment samples were collected from six locations over a six-month period spanning the dry (January-March) and wet (July-September) seasons of 2024 to assess spatial and temporal variations in MP abundance. MP concentrations varied considerably among sampling sites and seasons, ranging from below the detection limit to 174 particles kg^{-1} dry weight. Polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyvinyl chloride (PVC) and nylon were the dominant polymer types identified. The pronounced spatial and seasonal variability observed in the study highlights the influence of local environmental conditions and anthropogenic activities on MP accumulation within the Niger Delta and demonstrates that sediment contamination can vary substantially over relatively short spatial and temporal scales.

Yahaya *et al.* [121] looked at MP contamination in the Dukku and Kalgo Rivers in Kebbi State, northwestern Nigeria. Both rivers provide important ecosystem services, and are used as drinking and domestic water supplies as for irrigation by surrounding communities. Also, there are fisheries along the rivers. MPs were detected in all surface water samples, with concentrations ranging from 125.0 to 160.3 particles L^{-1} in the Dukku River and from 119.3 to 134.7 particles L^{-1} in the Kalgo River. Polyamide (PA) was the predominant polymer identified in both river systems, followed by polyethylene (PE). The widespread occurrence of MPs in these rivers highlights that freshwater plastic contamination is not restricted to highly urbanized catchments but also affects river systems that are vital for rural

livelihoods and water security.

Ololade *et al.* [48] investigated the occurrence and distribution of MPs in surface water and sediments of major rivers in southwestern Nigeria. Seasonal differences were observed between environmental compartments. Sediment MP concentrations ranged from 12.82 to 22.90 particles kg^{-1} dry weight during the dry season and from 5.69 to 14.38 particles kg^{-1} dry weight during the wet season. In contrast, surface water concentrations increased during the wet season, ranging from 12.41 to 22.73 particles L^{-1} , compared with 6.71 to 17.12 particles L^{-1} during the dry season. Fibres were the dominant morphology, representing approximately 71% of MPs in sediments and 67% in surface waters, while PE and PP were the predominant polymers. The contrasting seasonal patterns between sediments and surface water indicate that rainfall promotes MP mobilization and transport, whereas reduced flow conditions favor particle retention within sediments.

Shokunbi *et al.* [122] studied MP contamination and associated potentially toxic elements (PTEs) in sediments of the Odo-Ona and Ogun Rivers in southwestern Nigeria. MP abundances varied considerably between the two river systems, ranging from 66.6 ± 12.2 to 311 ± 20.8 particles kg^{-1} in the Ogun River and from 133 ± 50 to 433 ± 100 particles kg^{-1} in the Odo-Ona River. Polymer analyses identified polyethylene (PE), polypropylene (PP) and polyamide (PA) as the dominant plastic types. Polyethylene was the most abundant polymer in both rivers, accounting for 72.8% of MPs recovered from the Odo-Ona River and 59.7% from the Ogun River (0.5 - 5 mm size fraction). By jointly assessing MPs and PTEs, the study highlights the potential for river sediments to act as repositories for multiple contaminants and further demonstrates the widespread occurrence of MP pollution in freshwater systems of southwestern Nigeria.

The Osun River in southwestern Nigeria has also been identified as a highly contaminated freshwater system [50]. The river serves as an important source of domestic water for surrounding communities and is internationally recognized due to the UNESCO-listed Osun-Osogbo Sacred Grove. To assess MP contamination, five sampling sites were established across peri-urban and urban sections of the river at Owode, Riverside, Ojubo, Gbogan Road and Offatedo. Surface water MP concentrations ranged from 3791 ± 88 to $22,079 \pm 134$ particles L^{-1} , this being among the highest concentrations reported globally for river water. Spatial differences in MP abundance reflected increasing anthropogenic influence associated with the Oshogbo metropolitan area. Sediment concentrations ranged from 392 to 1590 particles kg^{-1} , with identified polymers including PET, PE, PVC, PU, ethylene-vinyl acetate (EVA), acrylonitrile butadiene styrene (ABS) and nylon. The study demonstrates the substantial influence of urban activities on MP contamination in culturally and ecologically significant freshwater systems [50].

Popoola *et al.* [54] compared MP contamination in two contrasting creek systems in southwestern Nigeria: Five Cowrie Creek, a brackish, tidally influenced estuarine channel connected to Lagos Lagoon and the Atlantic Ocean through Lagos Harbour, and Imakun Omi Ise Creek, a predominantly freshwater riverine

system. Five Cowrie Creek is situated within a densely urbanized environment and receives domestic sewage, industrial effluents and stormwater runoff, whereas Imakun Omi Ise Creek is surrounded by mangrove ecosystems and rural communities where fishing and farming are the dominant activities. Nevertheless, the freshwater creek is also affected by local dredging, aquaculture effluents, sawmill activities, residential wastewater discharges and seasonal flooding associated with inflows from Oyan Dam and high rainfall. MP concentrations in the freshwater Imakun Omi Ise Creek ranged from 100 to 230 particles L^{-1} in surface water and from 100 to 210 particles kg^{-1} in sediments. In comparison, the more heavily urbanized Five Cowrie Creek exhibited generally higher concentrations, ranging from 100 to 490 particles L^{-1} in surface water and from 70 to 220 particles kg^{-1} in sediments. Fibres were the dominant particle morphology in both creek systems. In Five Cowrie Creek, polypropylene (PP), polyamide (PA), polyethylene terephthalate (PET), polyethylene (PE), polystyrene (PS), acrylonitrile butadiene styrene (ABS) and ethylene-vinyl acetate (EVA) were identified, with PP being the predominant polymer in surface waters and PA dominating sediment samples. Similarly, PP, PA, PET and PE were the principal polymers detected in Imakun Omi Ise Creek. The comparison between these two systems demonstrates that both urbanized estuarine waterways and freshwater riverine environments can accumulate substantial quantities of MPs, although higher contamination levels are generally associated with dense urban development and multiple wastewater and industrial inputs.

Thomas and Egbinola [53] investigated MP contamination in the Ona River Basin in southwestern Nigeria by collecting 60 surface water samples across four hydrological seasons from multiple sites representing different environmental settings within the catchment. MP concentrations in surface water ranged from 31.5 to 74.9 particles L^{-1} . The study demonstrated clear links between urbanization and freshwater MP pollution, showing that population density, built infrastructure and land-cover transformation were closely associated with spatial differences in both physicochemical water characteristics and MP abundance. In a subsequent investigation, Thomas [123] further examined the influence of catchment morphology and seasonal hydrology on MP distribution across 12 sites within the basin. MP concentrations ranged from 16.93 to 77.67 particles L^{-1} , with the highest values recorded during the peak of the dry season. Fibres were the dominant particle type throughout the basin, while fragments, films and beads were more abundant in highly urbanized reaches. Lower-elevation river sections with wider and deeper channels exhibited greater MP accumulation, demonstrating that geomorphological characteristics, together with seasonal reductions in flow and dilution, strongly influence MP retention within the catchment. Together, these studies highlight that both anthropogenic pressures and natural catchment characteristics govern the occurrence and distribution of MPs within tropical river systems. In 2025, a further paper was published by the group on the Ona River System [124].

Ebere *et al.* [52] studied macroplastic debris and MPs in five rivers within Imo

State, southeastern Nigeria. Plastics represented approximately 59% of recorded macrodebris, exceeding other waste categories such as metals, cloth, paper/cardboard and rubber. The authors suggested that macroplastic assessments may provide useful preliminary indicators for identifying MP pollution hotspots, particularly in regions where detailed MP monitoring remains limited.

5.2.2. Ghana

Freshwater MP studies in Ghana have demonstrated contamination in both riverine and lacustrine environments, with research highlighting the influence of hydrological conditions, reservoir dynamics and industrial activities.

Blankson *et al.* [44] investigated MPs in lentic and lotic sections of the Densu River, including reservoir and delta environments. MPs were detected throughout the river system, demonstrating widespread contamination across different hydrological settings. Although average MP abundance did not differ significantly between the reservoir and delta environments, differences in hydrodynamic conditions influenced particle behavior. The stagnant reservoir environment promoted the retention of larger floating MPs, whereas the flowing delta environment exhibited less selective deposition between sediments and the water column. The study emphasized the importance of hydrological conditions in controlling MP transport and accumulation.

Boateng *et al.* [74] investigated MP contamination in sediments from the southern region of Lake Volta, one of Ghana's most important freshwater resources. The study reported a mean abundance of 13.3 ± 2.3 particles per 50 g dry sediment, representing relatively high contamination compared with several freshwater systems globally. Microfibres accounted for approximately 39% of recovered particles. Textile industries located near the lake were suggested as potential sources of fibre pollution through wastewater discharge. The findings highlight the vulnerability of large freshwater reservoirs to industrial and urban pressures.

5.2.3. Regional Synthesis: West Africa

Collectively, studies from West Africa demonstrate that MP contamination is widespread across freshwater ecosystems and is strongly influenced by anthropogenic activities. Rivers draining densely populated urban centres in Nigeria frequently exhibit some of the highest MP concentrations reported on the continent, reflecting the combined effects of rapid urbanization, inadequate solid waste management, untreated or poorly treated wastewater discharges and diffuse catchment runoff. Even higher MP abundances in both surface water and sediments were reported by Doherty *et al.* [125] in a nationwide assessment of seven major rivers (the Yauri, Benue, Argungu, Jamare, Ogun, Ethiopie and Orashi Rivers) spanning six geopolitical zones of Nigeria, highlighting the extensive distribution of MPs across the country's freshwater systems. Studies from Ghana similarly demonstrate that MP occurrence is governed by a combination of anthropogenic pressures and hydrological processes, with industrial activities, wastewater inputs and local flow conditions playing important roles in controlling the transport, re-

tention and accumulation of MPs within riverine and lacustrine environments. Across West African freshwater systems, fibres consistently dominate MP assemblages, indicating the importance of wastewater and textile-related sources. PE, PP, PET and PS are among the most frequently reported polymers, reflecting the widespread use of packaging materials, consumer plastics and synthetic fibres. Seasonal rainfall patterns strongly influence MP transport, with wet-season runoff increasing the mobilization of particles from terrestrial environments into aquatic systems.

Despite increasing research activity, major knowledge gaps remain regarding MP fate, long-distance transport, ecological impacts and the effectiveness of mitigation strategies. Improved wastewater treatment, enhanced solid waste management and catchment-based approaches will be essential to reduce MP inputs into West African freshwater ecosystems.

5.3. East Africa and the African Great Lakes

East Africa contains some of the continent's most important freshwater resources, including the African Great Lakes, major river systems and smaller inland lakes that support drinking water supplies, fisheries, agriculture, biodiversity and local livelihoods. Despite their ecological and socioeconomic importance, freshwater microplastic (MP) contamination in East Africa remains comparatively under-investigated. Available studies indicate that MPs are widespread throughout the region and are strongly associated with urbanization, wastewater inputs, shoreline activities, agricultural practices and catchment-scale land-use changes. Research from Uganda, Ethiopia, Kenya and Tanzania demonstrates that both highly populated urban catchments and more remote freshwater ecosystems are affected by plastic pollution.

5.3.1. Uganda and Lake Victoria Basin

Lake Victoria is Africa's largest lake by surface area and supports millions of people through fisheries, transport, agriculture and domestic water use. Due to its extensive catchment and surrounding densely populated areas, the lake receives plastic inputs from multiple sources, including urban runoff, wastewater discharge, shoreline activities and riverine transport.

Egessa *et al.* [81] investigated the occurrence, abundance and distribution of micro-, meso- and macroplastic debris in shoreline and lake sediments of northern Lake Victoria. MP abundance in shoreline sediments ranged from 0 - 1102 particles kg⁻¹ dry sediment, while lake sediment concentrations ranged from 0 - 108 particles kg⁻¹. Plastic films dominated shoreline sediments, accounting for more than 54% of recovered MPs, whereas filaments were the dominant morphology in lake sediments (>55%). Fourier-transform infrared spectroscopy (FTIR) analysis identified polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), polyamide (nylon) and polyvinyl chloride (PVC) as the major polymers. The study demonstrated that both local shoreline activities and catchment-derived inputs contribute to plastic accumulation within Lake Victoria sediments.

Ocakacon *et al.* [70] studied MP contamination in the Nakivubo Catchment in Uganda, which receives wastewater and stormwater from Kampala City before discharging into Lake Victoria through the Nakivubo Channel. A total of 117 surface water samples were collected during dry and wet seasons in 2022. Mean MP concentrations ranged from 1568.6 ± 1473.8 particles m^{-3} during the dry season to 2140.4 ± 3670.1 particles m^{-3} during the wet season. Based on measured concentrations and flow conditions, the authors estimated that the Nakivubo Catchment may discharge approximately 293.957 million MP particles per day into Lake Victoria. The highest MP concentration ($5.466.67 \pm 6.441.70$ particles m^{-3}) was recorded at a site characterized by poor solid waste management and inadequate wastewater handling. Fibres were the dominant morphology (79.7%), followed by fragments (17.9%), while PE accounted for 75.4% of identified polymers and polyethylene/polypropylene copolymers represented 16.0%. The study highlights the importance of urban wastewater and waste management practices in controlling MP inputs into Lake Victoria.

5.3.2. Ethiopia

Ethiopia has one of the fastest-growing plastic industries in Africa and is the second-largest importer of raw plastic materials in Central and Eastern Africa. Increasing plastic consumption, combined with challenges in waste management infrastructure, has contributed to growing concerns regarding plastic pollution. Government initiatives have increasingly focused on reducing plastic waste, although freshwater contamination remains insufficiently characterized.

Nigatu *et al.* [43] investigated the occurrence, abundance and composition of MPs in surface water and sediments of the Megech River and its tributaries, which discharge into Lake Tana, one of Ethiopia's most important freshwater systems. Sampling was conducted at 11 sites, and MPs were detected in both environmental compartments. The average abundance was 0.55 ± 0.31 particles L^{-1} in surface water and 19.39 ± 11.91 particles kg^{-1} in sediments. The study confirmed that river systems act as important pathways for transporting plastic particles into Lake Tana and demonstrated that Ethiopian freshwater ecosystems are affected by MP contamination despite comparatively limited industrial development in some catchments.

The Ethiopian lake Hawassa exhibited some of the highest levels of microplastics known in sediment (11,000 - 74,000 particles/kg), possibly driven by low turbulence, limited outflow, and long retention times [72].

Lake Ziway is one of Ethiopia's largest freshwater lakes and provides important ecosystem services, including drinking water supply, fisheries and agricultural support. Sediment samples from the lake [73] were analyzed to quantify plastic particle abundance and mass. Median plastic concentrations reached 30,000 particles m^{-3} (range: 400 - 124,000 particles m^{-3}) and 764 mg kg^{-1} dry weight (range: 0.05 - 36,233 mg kg^{-1} dry weight). The highest measured values exceeded published ecological effect thresholds, indicating that contamination in some areas may represent a potential risk to freshwater organisms. The study highlights the

vulnerability of important freshwater lakes to plastic accumulation and the need for improved monitoring and management strategies.

5.3.3. Kenya

Lake Naivasha is an important freshwater ecosystem in Kenya, supporting fisheries, agriculture, biodiversity conservation and surrounding communities. The lake receives inputs from rivers and tributaries draining a catchment characterized by agricultural activity, urban development and wastewater-related pressures.

Migwi *et al.* [45] investigated the occurrence, abundance and composition of MPs in surface waters of Lake Naivasha. Average MP concentrations ranged from 0.183 ± 0.017 to 0.633 ± 0.067 particles m^{-2} , with an overall mean concentration of 0.407 ± 0.135 particles m^{-2} . Polypropylene (PP), polyethylene (PE) and polyester (PES) were the dominant polymer types identified. Considerable spatial variability in MP abundance was observed among sampling locations, which the authors attributed to differences in human activities, water and wastewater inputs through rivers and tributaries, and local wind-driven circulation patterns influencing particle transport and accumulation. The study demonstrates the importance of combining catchment-scale pollution assessments with understanding of lake circulation processes when evaluating MP distribution.

5.3.4. Tanzania and the African Great Lakes

The African Great Lakes region represents a major freshwater resource area where increasing population density, urban development and shoreline activities contribute to growing plastic pollution concerns.

Mayoma *et al.* [80] assessed MP contamination in shoreline sediments of Lake Tanganyika during the rainy season. Triplicate sediment samples were collected from four sites representing different levels of anthropogenic influence: the Tanzania Fisheries Research Institute (TAFIRI), Kibirizi Market (KM), Katonga Fish Market (KFM) and Kusanya Stream (KS). Significant differences in MP abundance were observed among sites. The lowest concentration was recorded at TAFIRI (24.00 ± 2.88 particles kg^{-1}), followed by Kibirizi Market (116.28 ± 9.54 particles kg^{-1}), Katonga Fish Market (221.78 ± 32.36 particles kg^{-1}) and Kusanya Stream (312.67 ± 71.30 particles kg^{-1}). The increasing contamination gradient from relatively less impacted areas towards markets and stream discharge points demonstrates the strong influence of local anthropogenic activities on MP accumulation in shoreline sediments.

Kundu *et al.* [68] investigated MP contamination in the River Themí and its tributaries in Arusha, Tanzania, including river water, sediments and adjacent irrigated agricultural soils. Statistical analysis showed that MP abundance in river sediments exceeded concentrations in surface water, while concentrations in irrigated farm soils were approximately four times higher than those found in river sediments. A strong relationship was observed between MP abundance and macroplastic occurrence, suggesting that larger plastic debris represents an important source of secondary MPs. Polyethylene (PE) was detected in all analyzed

samples, while polystyrene (PS) was also abundant. The study highlights the connectivity between terrestrial and aquatic pollution pathways and demonstrates the role of agricultural practices and land-use activities in controlling MP distribution.

5.3.5. Regional Synthesis: East Africa and the African Great Lakes

Studies from East Africa demonstrate that MPs are widely distributed across major lakes, rivers and urban catchments. Lake Victoria, Lake Tanganyika, Lake Naivasha and Lake Tana all show evidence of plastic contamination, despite differences in catchment characteristics and levels of anthropogenic pressure. Urban areas with high population densities, inadequate wastewater treatment and poor solid waste management generally exhibit elevated MP concentrations, while agricultural activities and shoreline use represent additional important sources.

Fibres and fragments dominate most East African freshwater systems, reflecting wastewater inputs, textile sources and the degradation of larger plastic debris. PE and PP are consistently reported as dominant polymers, reflecting widespread use of packaging and consumer plastics. Seasonal rainfall, river discharge and local hydrodynamic conditions influence the movement and retention of MPs, particularly in lake environments where circulation patterns can determine accumulation zones.

Although research activity in East Africa is increasing, substantial knowledge gaps remain regarding MP transport pathways, ecological effects, long-term accumulation trends and the effectiveness of pollution reduction strategies. Improved waste management, wastewater treatment capacity and integrated catchment-scale monitoring will be essential for protecting the region's freshwater resources from increasing plastic contamination.

5.4. Southern Africa

Southern Africa represents one of the most extensively investigated regions on the African continent regarding freshwater microplastic (MP) contamination. Research has focused particularly on South Africa, with additional studies from Botswana and Namibia. Investigations have examined a wide range of freshwater environments, including major river systems, reservoirs, lakes, wastewater treatment plants (WWTPs), protected areas and arid-region rivers. Collectively, these studies demonstrate that MP contamination is widespread and influenced by a combination of urbanization, wastewater discharge, industrial and agricultural activities, diffuse catchment sources, hydrological processes and geomorphic controls.

5.4.1. South Africa

South Africa has a diverse range of freshwater systems that are subject to increasing anthropogenic pressures. Rapid urbanization, industrial development, intensive agriculture and variable wastewater treatment capacity have created multiple pathways for plastic inputs into rivers and reservoirs. The country's major river

systems, particularly the Vaal, Orange, Olifants, Sabie and coastal catchments, have been the focus of numerous MP investigations.

1) Vaal River system

The Vaal River is the principal tributary of the Orange River and forms part of South Africa's largest freshwater system. It is one of the country's most important water resources, supporting domestic, agricultural and industrial activities. Approximately 98% of the raw water used by Rand Water, South Africa's largest bulk water utility, is extracted from the Vaal River. Following purification, this water supplies approximately 11 million people across Gauteng, Mpumalanga, North West and Free State provinces. Due to its strategic importance and the intensive urban-industrial activities within its catchment, the Vaal River has been a major focus of freshwater MP research.

In 2022, Dahms *et al.* [63] published an investigation of MP contamination in sediments of the Upper Vaal River. Four sampling sites were assessed, and MPs were detected at all locations, with an average abundance of 46.7 particles kg⁻¹ dry weight. The highest concentrations were recorded at Vaal Rus (68 particles kg⁻¹), followed by Loch Vaal Club (53 particles kg⁻¹), Vaal Dam (48 particles kg⁻¹) and the site immediately downstream of the dam wall (18 particles kg⁻¹). MP abundance increased downstream from the Vaal Dam, suggesting additional inputs along the river course. Filaments were the dominant particle morphology, representing approximately 42% of recovered MPs.

Ramaremsa *et al.* [62] investigated MP contamination in the Vaal River between the Lethabo Weir and the Vaal Barrage, an area influenced by several tributaries, including the Suikerbosrand, Klip, Taaibosspruit, Leeuspruit and Rietspruit Rivers. Surface water and sediment samples collected in 2021 demonstrated elevated MP concentrations near tributary confluences. These tributaries transport wastewater effluent from southern Gauteng and parts of the northern Free State into the Vaal River, representing important pathways for plastic inputs. Fibres and fragments were the dominant morphologies in both water and sediment samples, while high-density polyethylene (HDPE), low-density polyethylene (LDPE) and polypropylene (PP) were the dominant polymers. The authors identified wastewater treatment plant effluent, urban runoff and tributary inflows as major potential MP sources and highlighted the need for improved WWTP infrastructure in the region.

Saad *et al.* [76] further assessed MP contamination in sediments by collecting 25 samples along a 75 km stretch of the Vaal River. Mean sediment MP abundance was 463.28 ± 284.08 particles kg⁻¹ dry weight, indicating substantially higher contamination than previously reported for parts of the river system. Identified polymers included HDPE, LDPE, PP, polyethylene-co-vinyl acetate (PEVA), polyester (PES) and polyurethane foam (PU). The authors identified wastewater effluent, anthropogenic activities, urban runoff, tributary inputs and recreational activities as potential sources of MPs. These findings reinforce the importance of multiple interacting pollution pathways within highly utilized river

catchments.

Beyond assessing MP sources, Weideman *et al.* [60] [61] investigated the transport and retention of MPs within the Orange-Vaal River system. In one study, the authors examined whether dams act as sinks for floating MPs by collecting bulk water and neuston net samples from five dams across the Orange and Vaal River systems [60]. Microplastic concentrations were relatively low, with mean values of 0.21 ± 0.27 particles L^{-1} in bulk water and 0.04 ± 0.16 particles m^{-2} in neuston samples. Microfibres represented the dominant particle type. Dams located within the densely populated and industrialized Vaal River catchment showed higher MP concentrations during dry conditions, whereas dams in the less industrialized Orange River catchment showed higher concentrations during wet conditions. However, no significant differences were observed between sites upstream and downstream of dam walls, and MP concentrations were not strongly correlated with distance from dam structures. The study concluded that dams within the Orange-Vaal system do not effectively trap floating MPs or microfibres.

In a subsequent study, Weideman *et al.* [61] investigated long-distance plastic transport through the Orange-Vaal River system. Surface water samples were collected from 33 bridge crossings during wet and dry seasons, covering the pathway from the highly urbanized Vaal catchment to the Atlantic Ocean. MPs and microfibres were detected at every sampling location, with average concentrations of 1.7 ± 5.1 particles L^{-1} . More than 99% of recovered particles were fibres, demonstrating the dominance of microfibres in transported plastic pollution. Microfibres were particularly abundant in the lower reaches during low-flow periods before seasonal flushing events. In contrast, larger plastic debris and macroplastics were substantially less abundant and were mainly detected in upper reaches of the Vaal River. The authors concluded that fine plastic particles can be transported over long distances, whereas larger plastics are generally retained closer to their source. Although the Orange-Vaal system may contribute microfibres to the Atlantic Ocean, it is unlikely to represent a major source of larger plastic debris under normal flow conditions.

Graham *et al.* [67] provided the first basin-scale assessment of microlitter distribution within the Orange-Senqu River basin. River water and sediment samples revealed substantial spatial variability, with sediment concentrations ranging from 0 - 4000 particles kg^{-1} dry weight and surface water concentrations ranging from 1.00 ± 0.71 to 69.75 ± 68.55 particles L^{-1} . No direct correlation was observed between sediment and water concentrations, indicating that MP accumulation in one environmental compartment does not necessarily reflect contamination in another. Using measured concentrations and river discharge data, the authors estimated microlitter transport rates ranging from approximately 889 particles s^{-1} to 17.9 million particles s^{-1} . A substantial proportion of transported material was expected to accumulate within the mudbelt near the Orange River mouth, demonstrating the role of large river systems in transferring land-based plastic pollution towards coastal environments.

Together, studies from the Vaal and Orange-Senqu systems demonstrate that large southern African rivers act as both transport pathways and temporary storage zones for MPs. Wastewater effluent, urban runoff, tributary inputs and industrial activities represent major sources, while hydrology, sediment characteristics and flow conditions determine particle transport and retention.

2) Catchment-scale and diffuse sources

In addition to studies focusing on individual rivers, De Villiers investigated microfibre contamination in sediments from lower reaches of catchments along South Africa's coastline [77]. Microfibre concentrations ranged from 0 to 567 fibres dm^{-3} , comparable with levels reported from sandy beach sediments along the coast. Regional differences were observed, with significantly higher microfibre concentrations in KwaZulu-Natal and the Wild Coast regions compared with the Cape south coast.

A significant positive relationship was identified between sediment microfibre abundance and the proportion of households within catchments without access to piped water. The study suggested that communities relying directly on rivers for domestic activities, including washing clothes in river water, may contribute substantially to diffuse microfibre contamination. These findings demonstrate that socioeconomic factors and household practices can influence freshwater MP pollution alongside more commonly recognized potential sources such as WWTPs and industrial discharges.

3) Urbanized and impacted river systems

Apetogbor *et al.* [64] investigated MP contamination in the Plankenburg River in Stellenbosch, Western Cape. Surface water concentrations were highest during spring (5.13 ± 6.62 particles L^{-1}) and lowest during autumn (1.52 ± 2.54 particles L^{-1}), while sediment concentrations reached 1587.5 ± 599.3 particles kg^{-1} during spring. Fibres between 500 - 1000 μm dominated recovered MPs. The elevated concentrations were linked to intense anthropogenic activity within the surrounding catchment.

Dahms *et al.* (2020) [57] studied the occurrence and distribution of MPs in the Braamfontein Spruit, an urban stream in Johannesburg, South Africa, by sampling nine sites. Mean MP concentrations were 705 particles m^{-3} in the water column and 166.8 particles kg^{-1} dry weight in the sediment. With the exception of one sediment sample, microfibers of various colors, likely originating predominantly from textiles, were the dominant microplastic type. The study further demonstrated that MP distribution is influenced by hydrological and physical factors, including water depth, flow velocity, and in-stream obstructions such as weirs. Moreover, the authors emphasized that assessing only a single environmental matrix, such as water, sediment, or biota, does not adequately represent the extent of microplastic contamination within the ecosystem. Instead, they advocate a multi-matrix approach that integrates both abiotic and biotic compartments to provide a more comprehensive assessment of microplastic pollution and to inform future sampling strategies.

Dalu *et al.* [78] [126] looked at the occurrence, distribution and seasonal variability of MPs in sediments collected from five sites along the intermittent Mvudi River in Limpopo Province, South Africa. The study specifically assessed the influence of urban development and wastewater treatment works on MP contamination within this subtropical river system. MP concentrations varied markedly among seasons, with substantially higher abundances recorded during the hot-wet season (76.0 ± 10.0 - 285.5 ± 44.5 particles kg^{-1}) than during the cool-dry (16.5 ± 4.5 - 27.0 ± 5.0 particles kg^{-1}) and hot-dry (13.0 ± 4.0 - 29.0 ± 10.0 particles kg^{-1}) seasons. Microfibres were the dominant particle type throughout the study. The pronounced increase in MP abundance during the wet season indicates that rainfall-driven runoff and enhanced transport from urban areas and wastewater treatment works play an important role in delivering MPs to the river. The findings further demonstrate that both seasonal hydrology and urban land use strongly influence MP contamination in South African freshwater systems.

Khan *et al.* [55] investigated seasonal MP variation in the Diep River, Western Cape, by sampling five locations along the river. Average surface water MP concentrations ranged from 1.25 - 5.25 particles L^{-1} during spring, 1.60 - 3.30 particles L^{-1} during autumn, and 2.15 - 3.80 particles L^{-1} during winter. The highest concentrations occurred near the Potsdam Wastewater Treatment Works, and the data is consistent with the importance of treated wastewater effluent as a source of MPs. Fibres were the dominant particle type, while PE and PS were the most common polymers identified.

The influence of urbanization on MP transport was further demonstrated by a year-long investigation of the Klip River, an urban river in Gauteng, South Africa [127]. Monthly surface water samples collected from six sites between November 2020 and October 2021 showed that MPs were present throughout the catchment, with mean monthly concentrations ranging from 0.18 to 2.90 particles L^{-1} . Fibres were the dominant particle morphology at all sampling locations. Land use exerted a strong influence on MP abundance, with reaches draining informal settlements exhibiting substantially higher concentrations than those associated with formal residential areas. MP fluxes increased progressively downstream, reflecting the cumulative contribution of urban runoff and catchment-scale inputs. Modelled annual MP fluxes increased from 9.69×10^8 particles year^{-1} at the uppermost site to 4.41×10^{10} particles year^{-1} at the downstream end of the catchment, while measured fluxes at the lowest site were approximately an order of magnitude higher (4.34×10^{11} particles year^{-1}). Although wetlands were expected to act as sinks for MPs, only one wetland-associated river reach exhibited a measurable reduction in MP flux. The study highlights the importance of urban land cover, particularly informal settlements, in driving MP inputs to river systems and demonstrates that cumulative downstream transport can substantially increase plastic loads delivered to receiving water bodies.

Microplastic contamination has also been investigated in the uMsunduzi River in KwaZulu-Natal and the Swartkops River in the Eastern Cape [65]. Sampling

locations represented areas influenced by urban runoff, agricultural activities, industrial discharge and WWTP effluent. Both river systems showed substantial sediment contamination, with the highest MP concentrations occurring in areas affected by industrial and agricultural activities. These studies further demonstrate the importance of surrounding land use and anthropogenic pressures in controlling MP accumulation within freshwater sediments.

Mvovo *et al.* [66] assessed the MP contamination in the Buffalo River, which flows through East London in the Eastern Cape and forms part of the uMzimvubu-Keiskamma Water Management Area. Surface water MP concentrations ranged from 0.35 - 0.75 particles L⁻¹ during the dry winter season and 0.30 - 0.90 particles L⁻¹ during the wet summer season. Sediment concentrations ranged from 3 - 32 particles kg⁻¹ during winter and 2 - 23 particles kg⁻¹ during summer. Fibres and fragments dominated, while PE and PP were the most frequently identified polymers. The study further demonstrated that MPs may act as carriers for heavy metals, with nickel, copper and iron detected on MP surfaces. Iron showed strong associations with the 3 mm and 1 mm particle size fractions, while copper was associated mainly with the 2 mm fraction.

Shikwambana *et al.* [59] investigated MP contamination in river water and sediments from the Olifants and Sabie Rivers within the Kruger National Park. Although these rivers flow through a protected area, their catchments receive upstream anthropogenic influences. A total of 36,984 MP particles were quantified, with significant differences in MP characteristics between rivers. Sediment concentrations ranged from 2022 - 9971 particles kg⁻¹ dry mass in the Olifants River and 2237 - 27259 particles kg⁻¹ dry mass in the Sabie River. Surface water concentrations ranged from 11 - 50 particles L⁻¹ in the Olifants River and 4 - 41 particles L⁻¹ in the Sabie River. PET was the dominant polymer, accounting for 39% of sediment MPs and 32% of water MPs. The study demonstrated that protected freshwater environments remain vulnerable to plastic pollution originating from upstream catchments.

4) Reservoir systems and population influences

Mutshekwa *et al.* [58] investigated MP contamination in four small reservoirs in the Vhembe District, Limpopo Province. Two reservoirs were located within densely populated formal and informal settlements in Shayandima Village, while two were situated in rural agricultural areas with lower population density. Sediment MP concentrations ranged from 84.74 - 374.76 particles kg⁻¹ dry weight during the dry season and 68.72 - 260.87 particles kg⁻¹ dry weight during the wet season. Surface water concentrations ranged from 6.07 - 21.77 particles per 100 L during the dry season and 7.33 - 19.27 particles per 100 L during the wet season. Reservoirs located near densely populated settlements showed significantly higher contamination than those in rural areas, demonstrating the influence of population density and associated human activities on freshwater MP accumulation.

5) Groundwater and spring systems

Extending investigations beyond rivers and reservoirs, a recent nationwide sur-

vey assessed MP contamination in 43 natural freshwater springs across six South African provinces between March and October 2024 [128]. The springs were distributed across the Eastern Cape ($n = 2$), Free State ($n = 1$), Gauteng ($n = 1$), KwaZulu-Natal ($n = 14$), Limpopo ($n = 24$) and Mpumalanga ($n = 1$), with approximately half located in rural settings and the remainder in peri-rural environments. Eighteen springs were considered largely unmodified by human activities. MPs were detected in 40 of the 43 springs, with concentrations ranging from 2 to 38 particles L^{-1} . Polyethylene (PE) was the dominant polymer, accounting for 46.8% of all identified particles, followed by polypropylene (PP; 22.3%), polyethylene terephthalate (PET; 13.4%), polystyrene (PS; 7.3%), polyvinyl chloride (PVC; 5.6%) and polyamide (PA; 3.5%). Despite differences in land use, spring type and geographic location, MP abundances showed substantial overlap among provinces, particularly between Limpopo and KwaZulu-Natal. These findings suggest that MP contamination is widespread even in groundwater-fed freshwater systems and may be driven by common regional sources or environmental transport pathways rather than solely by local land-use characteristics or spring morphology. The ubiquity of microplastics, including in groundwater, is commented on by researchers of other parts of Africa, also [129] [130].

6) Wastewater treatment plants as point sources

Wastewater treatment plants are increasingly recognized as important pathways for MP transport into freshwater environments because conventional treatment processes are not specifically designed for complete MP removal.

Sacko *et al.* [131] investigated MP removal efficiency at the Daspoort Wastewater Treatment Works (WWTW) in Pretoria, Gauteng. The plant serves Pretoria and operates several treatment processes, including a biological nutrient removal (BNR) process followed by ultraviolet (UV) disinfection as a tertiary treatment stage. Influent concentrations averaged 69 ± 13 MP L^{-1} , while the treatment process achieved approximately 80% MP removal efficiency. However, treated effluent still contained 13 ± 8 MP L^{-1} , demonstrating continued release of MPs into the receiving environment. Fibres represented approximately 70% of recovered MPs, while PE, PP, polyamide (PA) and PET were the dominant polymers. The study highlights that even advanced wastewater treatment systems remain significant pathways for MP discharge. This includes drinking water treatment plants [51].

Thus, Ramaremsa *et al.* [132] found microplastic in tap water in three suburbs in Gauteng Province. The concentrations ranged from 4.7 to 31 particles/L, with a mean of 14 ± 5.6 particles/L. These particles may stem from the release of microplastics from the drinking water treatment plant that provides the drinking water or from the pipes during the transportation of drinking water. This can be compared with results of drinking water treatment plants in other regions within Africa. Shokunbi *et al.* [133] looked at the efficiency of a drinking water treatment plant in Ogun State, Nigeria. The measured abundances of MPs were 16.13 ± 3.83 particles/L in raw water, 10.74 ± 3.76 particles/L in treated water, and 12.43 ± 3.92 particles/L in tap water. Most of the MPs found in the water samples were classi-

fied as fibres. The results indicated that DWTP reduced microplastics from raw water by 40%. However, there was an increase in the abundance of MPs in tap water. This highlights the problem of MP presence in drinking water in different African regions [134], including in South Africa [135] [136].

7) Geomorphic controls on MP distribution

Dahms and Greenfield [56] investigated the influence of geomorphic habitat units (GHUs) on MP distribution in the Nyl and Mogalakwena Rivers in Limpopo Province. Sampling sites represented different river habitat characteristics, including variations in riverbed composition, flow conditions and topography, while minimizing direct anthropogenic influences. The study demonstrated that MP distribution is strongly controlled by physical habitat characteristics. River depth, width, flow velocity, sediment properties and vegetation influence whether MPs are retained within sediments or transported downstream. The authors emphasized that environmental conditions should be considered when comparing MP concentrations between freshwater systems.

5.4.2. Botswana

Kelleher *et al.* [79] conducted the first investigation of MP contamination in surface sediments of the Okavango Panhandle in northern Botswana. The Okavango Panhandle represents the main inflowing watercourse of the Okavango Delta and functions as the primary depositional zone for sediments transported through the Cubango-Okavango River Basin.

MP concentrations in the 64 μm - 5 mm size fraction ranged from 56.7 to 399.5 particles kg^{-1} dry weight. When the finer 20 μm - 5 mm size fraction was considered, concentrations increased substantially, ranging from 1 075.7 to 1 756.3 particles kg^{-1} . The study demonstrated that even relatively remote freshwater systems with limited direct urban development are affected by MP contamination, emphasising the importance of catchment-scale transport processes in distributing plastic pollution through river networks.

5.4.3. Namibia

Faulstich *et al.* [75] investigated MP contamination in fluvial sediments across major Namibian catchments, with particular emphasis on the Iishana system in northern Namibia. Sediment sampling was conducted in 2019 and 2021 following rainy seasons, when episodic flow events facilitate transport within otherwise arid environments.

MPs were detected in all investigated river systems, with the highest concentrations recorded in the Iishana system, averaging 13.2 particles kg^{-1} dry weight. Polymer composition was similar across perennial rivers, ephemeral rivers and the Iishana system, with PE and PP dominating. Most particles occurred within the 0.3 - 0.5 mm and 0.5 - 1.0 mm size fractions and were primarily classified as fragments and films. Transparent and brown particles were the most common. The study demonstrated that MP contamination occurs even in arid and semi-arid freshwater environments, where episodic rainfall events can mobilize and redis-

tribute plastic particles.

5.4.4. Regional Synthesis: Southern Africa

Research from Southern Africa demonstrates that freshwater MP contamination is widespread across highly urbanized rivers, reservoirs, protected ecosystems and remote arid catchments. South African studies particularly highlight the importance of wastewater effluent, urban runoff, industrial activity and agricultural land use as potential major sources of MPs.

Fibres are consistently the dominant particle morphology, reflecting wastewater pathways, textile sources and diffuse household contributions. PE, PP, PET and PS are the most frequently identified polymers, reflecting their widespread use in packaging, consumer products and synthetic textiles.

A key finding from Southern African research is that MP distribution is governed not only by pollution sources but also by environmental processes. River flow, sediment characteristics, geomorphology, reservoir conditions and seasonal hydrology influence whether MPs are transported downstream or retained within sediments. Studies from the Orange-Vaal system demonstrate that fine particles, particularly microfibrils, can be transported over very long distances, while larger plastics tend to remain closer to their sources.

Despite substantial progress in understanding MP contamination in Southern Africa, important knowledge gaps remain regarding ecological impacts, long-term accumulation trends and effective mitigation strategies. Reducing freshwater plastic pollution will require integrated approaches combining improved waste management, upgraded wastewater treatment, catchment-scale monitoring and consideration of both point and diffuse pollution sources.

6. Overall Trends and Knowledge Gaps in African Freshwater Sediment Microplastic Contamination

Across African freshwater systems, microplastic (MP) contamination has been documented in a wide range of environments, including major rivers, reservoirs, lakes, wetlands and wastewater-impacted systems. Although reported concentrations differ substantially among studies due to variations in sampling strategies, particle size ranges, analytical methods and reporting units, the available evidence demonstrates that MPs are widespread throughout the continent's freshwater environments.

A consistent pattern emerging from studies across Africa is the strong influence of anthropogenic activities on MP occurrence and distribution. Urbanized catchments generally exhibit elevated MP concentrations due to increased plastic consumption, inadequate waste management, stormwater runoff and wastewater discharge. Rivers receiving effluent from wastewater treatment plants (WWTPs), such as the Vaal, Diep, Daspoort and Nakivubo systems, demonstrate that treated wastewater remains an important pathway for MPs entering aquatic environments. Although modern treatment processes can substantially reduce MP loads, they do not achieve complete removal, allowing considerable numbers of parti-

cles, particularly fibres, to be discharged into receiving waters. It must be noted, however, that along the Mvudi river the MP distribution and type generally varied, however, with the impact of the wastewater treatment plant (at Thohoyandou) not apparent [78]. In fact, in some cases the MP concentrations were lower downstream of the plant, suggesting that the wastewater treatment plant was playing some role in removing microplastic, or influencing loadings via dilution effects (due to the pumping-in of wastewater).

Catchment land use is a major determinant of MP contamination patterns. Studies from South Africa, Nigeria, Uganda, Tanzania and Tunisia consistently show higher MP concentrations in areas influenced by dense populations, industrial activities, agricultural production and municipal wastewater inputs. For example, increased contamination in the Vaal River, Osun River, Nakivubo Catchment and Bizerte streams was strongly associated with urban development and anthropogenic pressures. Similarly, studies from reservoirs and lakes, including those in Ethiopia, Tunisia and South Africa, demonstrate that surrounding land use strongly influences MP accumulation within sediments.

Seasonal variability is another important factor controlling MP transport and deposition. In many African freshwater systems, wet seasons are associated with increased MP concentrations in surface waters due to enhanced runoff, erosion and mobilization of plastic debris from terrestrial environments. This pattern was observed in systems such as the Nakivubo Catchment, Ona River Basin and several Nigerian rivers. However, some studies reported higher sediment concentrations during dry periods, likely due to reduced flow velocities, lower dilution effects and enhanced particle settling. These contrasting seasonal patterns demonstrate that rainfall and hydrological conditions influence not only MP inputs but also their movement between water and sediment compartments.

Across almost all investigated freshwater environments, fibres represent the dominant MP morphology. Fibres accounted for the majority of particles in many rivers, lakes and sediments, including the Nile, Vaal, Buffalo, Osun, Nakivubo and Ikpoba Rivers. Their widespread occurrence is generally linked to domestic wastewater, textile-related activities, fishing practices and insufficient removal during wastewater treatment. Fragments are the second most commonly reported particle type and are associated with the breakdown of larger plastic items. In some environments, such as river sediments and agricultural soils, films, beads and pellets have also been identified, reflecting differences in local plastic sources and transport processes.

Polymer composition across African freshwater systems is dominated by a relatively small group of widely used plastics. Polyethylene (PE) and polypropylene (PP) are the most frequently reported polymers, reflecting their extensive use in packaging, consumer products, agricultural materials and household applications. Polyethylene terephthalate (PET), polystyrene (PS), polyamide (PA), polyurethane (PU) and polyvinyl chloride (PVC) are also commonly detected, depending on local activities and pollution sources. The dominance of PE and PP indicates

that consumer packaging and domestic plastic waste represent important contributors to freshwater contamination across the continent.

Environmental conditions strongly influence MP retention, transport and accumulation. River morphology, sediment characteristics, flow velocity, vegetation, hydrological connectivity and geomorphic habitat units determine whether MPs remain trapped locally or are transported downstream. Studies from the Orange-Vaal River system demonstrate that fine particles, particularly microfibres, can be transported over long distances, while larger plastic debris generally remains closer to its source. Similarly, investigations of dams and reservoirs indicate that these systems do not necessarily function as permanent sinks for floating MPs, with hydrodynamic conditions controlling particle movement more than simple physical barriers.

Despite increasing research activity, significant knowledge gaps remain regarding MP contamination in African freshwater environments. Research remains geographically uneven, with relatively extensive datasets available from countries such as South Africa, Nigeria, Ghana, Uganda and Tunisia, while many regions, particularly Central Africa and parts of North and West Africa, remain poorly characterized. Furthermore, comparisons between studies remain difficult because of differences in sampling approaches, extraction methods, size fractions analyzed and reporting units.

Future research should focus on improving methodological harmonization, increasing monitoring coverage and developing long-term datasets capable of assessing temporal trends. Greater attention is also required on MP transport pathways, interactions with other contaminants, ecological impacts and the effectiveness of mitigation measures. In particular, further investigation of wastewater treatment systems, diffuse household sources, agricultural pathways and urban stormwater networks is needed to better understand the mechanisms driving freshwater contamination.

Overall, current evidence indicates that MP pollution is widespread across African freshwater ecosystems and reflects the interaction between human activities, waste management practices, wastewater inputs, catchment characteristics and hydrological processes. Effective management will require integrated catchment-scale strategies combining improved plastic waste management, enhanced wastewater treatment technologies, pollution prevention and coordinated monitoring programs to reduce the transfer of plastics from inland freshwater systems to coastal and marine environments.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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