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Plastic and Microplastic Pollution in the Nile River and the Eastern Mediterranean: Sources, Occurrence, Ecological and Human-Health Risks

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Abstract

Plastic pollution has become one of the most pervasive forms of environmental contamination, and the semi-enclosed Mediterranean Sea is among the most plastic-polluted water bodies in the world. Rivers are major conduits of land-based plastic to the sea, yet the Nile, the longest river on Earth and the lifeline of Egypt and Sudan, was not studied for microplastics until 2020. This review synthesises global and regional evidence on the sources, transport, occurrence and effects of plastics and microplastics (particles smaller than 5 mm) in the Nile basin and the eastern Mediterranean. Egypt was estimated in 2010 to be among the ten countries generating the largest mass of mismanaged plastic waste in coastal populations. The first studies in the Nile found microplastics in the digestive tracts of more than 75% of fish sampled in Cairo, and in every fish examined in a later study at Khartoum, with fibres and fragments dominating. Microplastics have also been reported in water, sediments and invertebrates of the Upper Egyptian Nile and in coastal waters and beaches of the Egyptian Mediterranean. The ecological consequences include physical damage, reduced feeding and transfer of associated chemical additives, while human exposure occurs through fish, drinking water, salt and air; health effects remain uncertain but are a growing concern. The review identifies the weaknesses of current evidence, particularly methodological heterogeneity and small sample sizes, and proposes priorities for waste management, monitoring and regulation in the region.

Keywords: *microplastics; plastic waste; Nile River; Mediterranean Sea; freshwater fish; Nile tilapia; mismanaged waste; human exposure; monitoring*

1. Introduction

Global plastic production has grown from a few million tonnes in the 1950s to more than 400 million tonnes per year. A substantial fraction of plastic waste is mismanaged: dumped, burned in the open or lost to the environment. Jambeck et al. (2015) estimated that 4.8 to 12.7 million tonnes of plastic entered the oceans from coastal populations in 2010, and ranked countries by the mass of mismanaged plastic waste they generate; Egypt was among the top ten. Once in the environment, plastics fragment under sunlight, abrasion and biological action into microplastics, particles smaller than 5 mm, and further into nanoplastics.

Rivers are the main pathway from land to sea. Global models initially suggested that a small number of large Asian rivers dominate river-borne plastic inputs to the ocean (Lebreton et al., 2017), but more recent modelling indicates that more than 1,000 rivers account for most of the emissions, with small urban rivers in densely populated coastal areas being disproportionately important (Meijer et al., 2021). The Nile, which passes through megacities such as Khartoum and Cairo and discharges into the Mediterranean through a densely populated delta, is therefore an important but under-studied system.

This review covers (i) sources and pathways of plastic in the Nile basin, (ii) evidence of microplastics in the Nile and the eastern Mediterranean, (iii) ecological and human-health effects, and (iv) policy and research priorities.



Figure 1. Locations of published microplastic studies along the Nile, on a NASA Blue Marble satellite composite: Khartoum (Sudan), Aswan, Nagaa Hammadi and Assiut (Upper Egypt), Cairo and the Nile Delta outlets to the Mediterranean. Most of the river's length between these sites remains unsampled.

2. Sources and pathways

2.1 Land-based waste

The dominant source of plastic in the Nile is inadequately managed municipal solid waste. Collection coverage in Egyptian cities has improved, but informal dumping on canal and drain banks, open burning and leakage from dump sites remain common, particularly in peri-urban and rural areas where collection services are weak. Irrigation canals and agricultural drains, which crisscross the Nile Valley and Delta, act as collectors of litter that is eventually flushed to the main river or to the northern lagoons.

2.2 Wastewater and sludge

Synthetic textile fibres released during washing, fragments from personal-care products and tyre-wear particles reach rivers through wastewater. Treatment plants remove a large share of microplastics from the liquid stream, but retain them in sludge, which is often applied to farmland. Untreated wastewater discharges, which still occur in parts of Egypt and Sudan, deliver microplastics directly to watercourses.

2.3 Agriculture and fisheries

Plastic mulch, greenhouse films, irrigation pipes and fertiliser bags are widely used in Egyptian horticulture, especially in reclaimed desert lands, and degrade in the field. Fishing gear and aquaculture equipment in the Nile and in the northern delta lagoons, which host a major share of Egypt's fish production, are additional sources.

2.4 Tourism and recreation

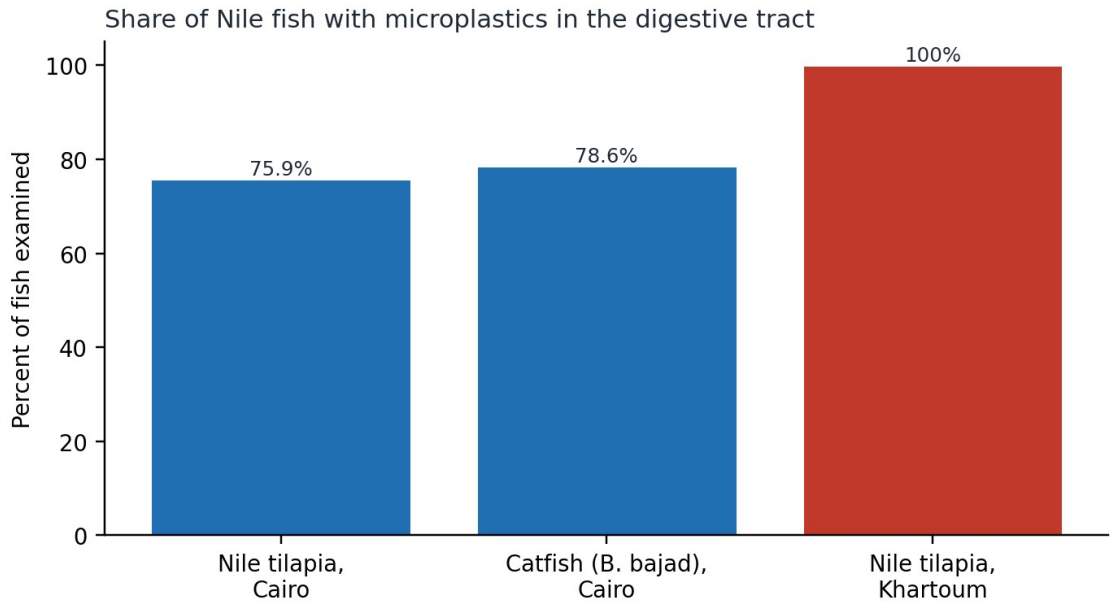
Riverside recreation, Nile cruises and coastal tourism contribute litter, especially single-use bottles, bags and food packaging. Saad (2024) identified riverside recreation and the lack of waste-collection facilities along the Nile in Khartoum as probable sources of microplastics found in local fish.

3. Occurrence in the Nile basin

3.1 Fish

The first evidence of microplastics in the Nile came from Khan et al. (2020), who examined the gastrointestinal tracts of Nile tilapia (*Oreochromis niloticus*, n = 29) and catfish (*Bagrus bajad*, n = 14) purchased in Cairo. Microplastics were found in 75.9% of tilapia and 78.6% of catfish, mostly fibres, and polymer identification by Fourier-transform infrared spectroscopy confirmed common plastics such as polyethylene and polypropylene. The authors noted that this level of ingestion is rarely found in comparable freshwater and marine studies.

In Sudan, a study of 30 Nile tilapia bought at the Al-Mawrada market in Omdurman, just downstream of the confluence of the Blue and White Niles, found microplastics in every specimen, with a total of 567 particles and between 5 and 47 particles per fish, dominated by fibres (Saad, 2024).



Sources: Khan et al. (2020), n = 29 tilapia and 14 catfish; Saad & Alamin as reported by Saad (2024), n = 30 tilapia, 567 particles, 5–47 per fish.

Figure 2. Proportion of Nile fish containing microplastics in the digestive tract in the first studies from Cairo and Khartoum. Sample sizes are small, and the studies used different methods; the results show widespread contamination but are not directly comparable.

3.2 Water, sediments and invertebrates

Studies in Upper Egypt in 2022 documented meso- and macroplastics in water, sediments, fish and crayfish (*Procambarus clarkii*) at sites in the Aswan, Qena and Assiut governorates, with the highest abundance in water and sediment at Nagaa Hammadi, an urban and industrial centre; African catfish carried the most plastic, whereas no meso- or macroplastics were found in tilapia guts or gills (Hassan et al., 2023). Khedre et al. (2024) reported microplastic concentrations of about 2.2–3.8 particles per litre in surface water and about 300–520 particles per kilogram of dry sediment in a seasonal survey of the Nile in Upper Egypt, with microplastics also present in aquatic insects, and assessed the ecological risk as high. A subsequent study extended sampling to four Upper Egyptian sites from Edfu to El-Minya and reported microplastics in water, sediment and the alimentary canals and gills of tilapia, African catfish and crayfish, with the highest abundances in water and sediment at Edfu, a tourist centre, and in fish digestive tracts at Nagaa Hammadi. Data for the Nile in the Delta and its branches, and for the irrigation and drainage network, remain sparse.

3.3 The Eastern Mediterranean and the Egyptian coast

The Mediterranean is semi-enclosed, with a long water-residence time and dense coastal populations, which make it an accumulation zone for floating plastic. Cózar et al. (2015) found plastic concentrations in Mediterranean surface waters comparable to those in the subtropical ocean gyres and estimated a total floating load of roughly 750 to 3,000 tonnes. Studies along the Egyptian coast, including beaches near Alexandria and the delta coast, have reported microplastics in surface water, sediments and marine organisms, with fragments and fibres of polyethylene and polypropylene dominating. Eastward-flowing currents along the southern Mediterranean coast carry Nile-derived plastic towards the Levantine basin.

4. Ecological effects

Laboratory and field studies show that microplastics can be ingested by organisms ranging from zooplankton to fish and birds. Effects documented in laboratory exposures include physical damage to the gut, false satiation and reduced feeding, oxidative stress, inflammation, and reduced growth and reproduction, although many studies used concentrations far higher than those found in the environment (Rochman, 2018). Microplastics also carry chemical additives (such as phthalates, bisphenols and flame retardants) and can sorb hydrophobic pollutants and metals from water; the significance of this "vector" effect relative to direct exposure remains debated. In a river like the Nile, which already receives agricultural pesticides, industrial effluents and untreated sewage, microplastics add to a mixture of stressors whose combined effects on fish, invertebrates and the food web are poorly understood.

5. Human exposure and health

Humans are exposed to microplastics through food, especially fish and shellfish eaten whole, drinking water, table salt and inhalation of airborne particles. A systematic review of microplastics in freshwater and drinking water found widespread occurrence but highlighted large differences in methods and quality control among studies (Koelmans et al., 2019). Plastic particles have been detected in human blood (Leslie et al., 2022) and other tissues. Toxicological evidence for health effects at realistic exposures remains limited, and international assessments have called for better data before firm conclusions can be drawn. In Egypt and Sudan, where Nile tilapia and catfish are staple and affordable sources of protein, and where the river supplies drinking water to tens of millions of people, the exposure pathway through fish and water deserves particular attention. Removing the gut before cooking reduces direct ingestion of particles retained in the digestive tract, although particles in gills and tissue are not removed.

6. Evidence gaps and methodological issues

The current evidence base for the Nile has important weaknesses that limit quantitative conclusions. Table 1 summarises them.

Table 1. Key limitations of current microplastic evidence for the Nile basin and recommended remedies

Limitation	Consequence	Recommended remedy
Few studies and small sample sizes	Large uncertainty; limited spatial coverage	Coordinated basin-wide sampling campaigns
Heterogeneous sampling and extraction methods	Results not comparable between studies	Adopt harmonised protocols (e.g., GESAMP, ISO)
Limited polymer verification	Misidentification of natural fibres	FTIR or Raman confirmation of a representative subset
Weak blank and contamination controls	Overestimation, especially of fibres	Field and laboratory blanks; clean-air procedures
No time series	Trends unknown	Fixed monitoring stations along the river
Little data on drinking water and food	Exposure uncertain	Targeted studies of treated water, fish, salt
Nanoplastics not measured	Smallest, potentially most	Develop and apply specialised

	bioavailable fraction missed	analytical methods

7. Policy and management priorities

1. **Waste collection and disposal.** Extending formal waste collection to rural and peri-urban areas, closing open dumps near watercourses and supporting the informal recycling sector are the most effective measures to reduce plastic leakage. Egypt's national solid-waste law of 2020 provides a framework for extended producer responsibility.
2. **Single-use plastic reduction.** Restrictions on single-use bags, already adopted in the Red Sea governorate, can be scaled up nationally, accompanied by alternatives.
3. **Wastewater treatment and sludge management.** Expanding treatment coverage, including rural sanitation, intercepts microplastics; sludge applied to land should be monitored.
4. **Interception at drains and canal outfalls.** Booms and trash racks at drain outlets to the Nile and to the northern lagoons can capture macroplastics before fragmentation.
5. **Agricultural plastics.** Collection and recycling schemes for greenhouse films and mulch in reclaimed lands, and promotion of biodegradable alternatives where appropriate.
6. **Monitoring and regional cooperation.** A Nile-basin microplastic monitoring programme linked to the Barcelona Convention's Mediterranean monitoring framework would provide comparable data from source to sea.
7. **Public awareness.** Riverside clean-ups and education campaigns raise awareness, though they cannot substitute for systemic waste management.

8. Conclusions

The Nile and the eastern Mediterranean are exposed to substantial plastic pollution driven by mismanaged waste in rapidly growing cities. Although research began only in 2020, every published study has found microplastics in Nile fish, often at high prevalence, and in water and sediments, indicating pervasive contamination. The ecological and human-health consequences remain uncertain, but the scale of exposure for populations that rely on the river for food and drinking water justifies precautionary action. Improving waste collection, reducing single-use plastics, expanding wastewater treatment and establishing harmonised, basin-wide monitoring are the priorities. Because plastic leakage is fundamentally a waste-management problem, the solutions lie as much in municipal services and product design as in environmental science.

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References

Cózar, A., Sanz-Martín, M., Martí, E., González-Gordillo, J. I., Ubeda, B., Gálvez, J. Á., Irigoien, X., & Duarte, C. M. (2015). Plastic accumulation in the Mediterranean Sea. PLoS ONE, 10(4), e0121762. https://doi.org/10.1371/journal.pone.0121762

Hassan, Y. A. M., Badrey, A. E. A., Osman, A. G. M., & Mahdy, A. (2023). Occurrence and distribution of meso- and macroplastics in the water, sediment, and fauna of the Nile River, Egypt. Environmental Monitoring and Assessment, 195, 1130. https://doi.org/10.1007/s10661-023-11696-7

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771. https://doi.org/10.1126/science.1260352

Khan, F. R., Shashoua, Y., Crawford, A., Drury, A., Sheppard, K., Stewart, K., & Sculthorp, T. (2020). 'The Plastic Nile': First evidence of microplastic contamination in fish from the Nile River (Cairo, Egypt). Toxics, 8(2), 22. https://doi.org/10.3390/toxics8020022

Khedre, A. M., Ramadan, S. A., Ashry, A., & Alaraby, M. (2024). Abundance and risk assessment of microplastics in water, sediment, and aquatic insects of the Nile River. Chemosphere, 353, 141557.

Koelmans, A. A., Mohamed Nor, N. H., Hermsen, E., Kooi, M., Mintenig, S. M., & De France, J. (2019). Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. Water Research, 155, 410–422. https://doi.org/10.1016/j.watres.2019.02.054

Lebreton, L. C. M., van der Zwet, J., Damsteeg, J.-W., Slat, B., Andrady, A., & Reisser, J. (2017). River plastic emissions to the world's oceans. Nature Communications, 8, 15611. https://doi.org/10.1038/ncomms15611

Leslie, H. A., van Velzen, M. J. M., Brandsma, S. H., Vethaak, A. D., Garcia-Vallejo, J. J., & Lamoree, M. H. (2022). Discovery and quantification of plastic particle pollution in human blood. Environment International, 163, 107199. https://doi.org/10.1016/j.envint.2022.107199

Meijer, L. J. J., van Emmerik, T., van der Ent, R., Schmidt, C., & Lebreton, L. (2021). More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean. Science Advances, 7(18), eaaz5803. https://doi.org/10.1126/sciadv.aaz5803

Rochman, C. M. (2018). Microplastics research—from sink to source. Science, 360(6384), 28–29. https://doi.org/10.1126/science.aar7734

Saad, D. (2024, February). Microplastics found in Nile River fish: Toxic pollution threatens world's longest river. The Conversation. Republished by Down To Earth. https://www.downtoearth.org.in/africa/microplastics-found-in-nile-river-s-tilapia-fish-new-study-94319