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Sundarbans Under Microplastics Threat — The Blue Carbon Crisis

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Sundarbans Under Microplastics Threat — The Blue Carbon Crisis

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WHY IN NEWS

Research from **IISER Kolkata** reveals that **microplastics are disrupting both the food web and the carbon cycle** in the **Sundarbans** — the world’s largest mangrove forest and a **UNESCO World Heritage Site**. Microplastic concentrations surge approximately **40% during the monsoon season**, with ~50% being **textile fibres**. “**Plastispheres**” — microbial communities that form on degrading plastic surfaces — act as **artificial carbon sources**, potentially reducing the Sundarbans’ efficiency as a **blue-carbon ecosystem** that captures and stores atmospheric CO₂.

THE SUNDARBANS — ECOLOGICAL SIGNIFICANCE

What Makes Sundarbans Unique

The **Sundarbans** spans the delta of the Ganga, Brahmaputra, and Meghna rivers across India (West Bengal) and Bangladesh, covering approximately **10,000 sq km** (4,263 sq km in India; rest in Bangladesh):

FEATURE	VALUE
Total area	~10,000 sq km
India’s share	~4,263 sq km (West Bengal)
Bangladesh’s share	~5,765 sq km
Forest type	Tidal halophytic mangrove
UNESCO WHS	1987 (India’s Sundarbans NP)
Ramsar Wetland	1992
Tiger Reserve	Yes — Sundarbans Tiger Reserve
Key species	Royal Bengal tiger, saltwater crocodile, Irrawaddy dolphin, Gangetic dolphin, Olive Ridley turtle

Blue Carbon Significance

Blue carbon refers to carbon captured and stored by **coastal and marine ecosystems** — mangroves, seagrasses, and salt marshes. These ecosystems:

- Sequester carbon **3-5 times faster per unit area** than tropical forests
- Store carbon for thousands of years in waterlogged sediments (anoxic conditions prevent decomposition)
- Provide **storm surge protection, coastal erosion prevention, and fisheries nursery services**

The Sundarbans stores an estimated **54-57 million tonnes of carbon** — making it one of the most significant blue carbon stores in Asia.

THE MICROPLASTICS CRISIS

What Are Microplastics?

Microplastics are plastic particles **less than 5 millimetres** in size. They originate from:

- 1 **Primary microplastics** — manufactured at micro-size (microbeads in cosmetics, pellets in plastic manufacturing)
- 2 **Secondary microplastics** — fragmentation of larger plastics through UV radiation, physical abrasion, and biological degradation

Nanoplastics are sub-micron particles (< 1 micrometres) formed from further weathering of microplastics.

Sources in the Sundarbans

The Sundarbans receives plastic pollution from:

- **Ganga river system** — carrying plastic waste from densely populated Gangetic cities (Kolkata, Patna, Varanasi, Delhi)
- **Local fisheries** — discarded nets, ropes, and packaging
- **Tourism** — boats and visitor waste
- **Coastal communities** — inadequate solid waste management in the Sundarbans fringe

The **monsoon surge of 40%** in microplastic concentrations reflects the annual flush of accumulated river plastics into the delta during high-flow season.

The Textile Fibre Dominance

Approximately **50% of Sundarbans microplastics are textile fibres** (polyester, nylon, acrylic). These originate from:

- **Washing synthetic clothing** — each wash releases thousands of fibres per garment
- **Fishing nets and ropes** — synthetic rope degradation
- These fibres are particularly problematic because they are **difficult for organisms to expel** after ingestion

THE PLASTISPHERE — A NEW ECOLOGICAL CONCERN

What Is a Plastisphere?

A **plastisphere** is a **microbial community** that forms on the surface of plastic debris in aquatic environments. As plastics weather and fragment:

- 1 Microbial biofilms colonise the plastic surface
- 2 The plastic leaches **dissolved organic carbon (DOC)** as it degrades
- 3 The DOC feeds rapid microbial growth
- 4 These microbial communities can include **pathogenic bacteria, antibiotic-resistant microbes,** and novel species

The Carbon Cycle Disruption

The IISER Kolkata study found that plastispheres in the Sundarbans act as **artificial carbon sources**:

NATURAL CYCLE	WITH PLASTISPHERES
Mangrove leaf litter → organic carbon → sediment storage	Plastic DOC → microbial respiration → CO ₂ release
Carbon sequestration enhanced by anoxic sediments	Plastisphere microbes alter sediment chemistry
Stable long-term carbon storage	Carbon leakage from ecosystem

In effect, plastics introduce **non-natural carbon inputs** that alter the microbial metabolism of the sediment, potentially converting the Sundarbans from a **carbon sink into a partial carbon source**.

FOOD WEB DISRUPTION

Microplastics enter the Sundarbans food web at multiple levels:

LEVEL	ORGANISM	IMPACT
Primary	Phytoplankton, zooplankton	Ingestion reduces feeding efficiency; toxin accumulation
Secondary	Small fish, crustaceans, molluscs	Bioaccumulation; gut blockage; hormonal disruption
Tertiary	Larger fish, birds, dolphins	Biomagnification; reproductive impairment
Apex	Royal Bengal tiger, saltwater crocodile	Highest toxin loads from biomagnification

Irrawaddy dolphins and **Gangetic dolphins** — both endangered species in the Sundarbans — are particularly vulnerable as they are at the apex of the aquatic food chain.

REGULATORY FRAMEWORK

India's plastic pollution governance:

REGULATION	PROVISION
Plastic Waste Management Rules, 2016 (amended 2022)	Banned single-use plastics below defined sizes
EPR (Extended Producer Responsibility)	Plastic producers responsible for collecting and recycling
Plastic Waste Management Amendment Rules, 2024	Strengthened EPR framework
Microplastics	No specific regulation yet — a governance gap

No Indian law specifically regulates microplastics — a critical gap identified by environmental researchers. The EU has proposed **microplastic labelling requirements** for cosmetics and has restricted intentionally added microplastics.

UPSC RELEVANCE

PAPER	ANGLE
GS3 — Environment	Microplastics, blue carbon, mangroves, Sundarbans ecology
GS1 — Geography	Ganga-Brahmaputra delta, Sundarbans geography, mangrove forests
GS3 — Economy	Blue economy, fisheries, coastal livelihoods
GS2 — Governance	Plastic regulation, EPR, environmental law gaps
Mains Keywords	Microplastics, plastisphere, blue carbon, Sundarbans, mangroves, EPR, Ramsar, UNESCO WHS, Irrawaddy dolphin

FACTS CORNER

- **Sundarbans area:** ~10,000 sq km; India (~4,263 sq km), Bangladesh (~5,765 sq km)
- **UNESCO WHS:** 1987 (India's Sundarbans National Park)
- **Ramsar designation:** 1992
- **Microplastic monsoon surge:** ~40% increase in concentration
- **Textile fibre share:** ~50% of Sundarbans microplastics
- **Blue carbon:** Carbon stored in mangroves, seagrasses, salt marshes — stored 3-5x faster than tropical forests
- **Sundarbans carbon storage:** ~54-57 million tonnes estimated
- **Plastisphere:** Microbial communities on plastic debris; leaches dissolved organic carbon
- **Key endangered species:** Irrawaddy dolphin (IUCN Vulnerable), Gangetic dolphin (Endangered), Royal Bengal tiger
- **Plastic Waste Management Rules, 2022:** Single-use plastic ban; EPR framework
- **Microplastics regulation gap:** No specific Indian law — a critical governance absence
- **IISER Kolkata:** Indian Institute of Science Education and Research, Kolkata — a national importance institution under MoE

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