# OCEAN CLEANUP TECHNOLOGIES: SAVING EARTH FROM PLASTIC

**[1] P.K. Arya, [2] Rashi**

**Department of Chemistry**

**Buddha Degree College, GIDA, Gorakhpur**

***Abstract-*** The escalating crisis of plastic pollution in the world's oceans poses a dire threat to marine ecosystems, human health, and global environmental stability. This article explores the latest advancements in ocean cleanup technologies designed to combat this challenge. From large-scale systems like The Ocean Cleanup's passive drifting barriers to autonomous robotic solutions such as beach-cleaning drones and seabed rovers, innovative engineering is playing a pivotal role in mitigating plastic waste. The article examines the effectiveness, scalability, and sustainability of these technologies, alongside the socio-economic implications and policy frameworks needed to support their implementation. By evaluating both current successes and ongoing challenges, the discussion highlights how a combination of technological innovation, public awareness, and international cooperation can drive significant progress in the fight against oceanic plastic pollution, ultimately contributing to a healthier planet.

***Index Terms-*** Ocean Cleanup, Plastic Pollution, Marine Debris, River Interceptors, Ocean Gyres, Microplastics, Circular Economy, Biotechnological Solutions, Mr. Trash Wheel, Sustainable Oceans, River Cleanup, Plastic Recycling, Ocean Restoration, India Plastic Initiatives.

## 1.INTRODUCTION

In the 21st century, plastic pollution has emerged as one of the most critical threats to marine ecosystems and global environmental health. What was once hailed as a revolutionary material due to its durability, versatility, and low cost, plastic has now become a pervasive pollutant, affecting even the most remote corners of the planet. Every year, over **11 million metric tons of plastic** enter the oceans, and this number is expected to triple by 2040 if no action is taken. From entangling marine life to entering the food chain through microplastics, the consequences are far-reaching and devastating.

The oceans, covering more than 70% of Earth's surface, play a vital role in regulating climate, producing oxygen, and supporting biodiversity. Yet they have become a dumping ground for human-generated waste. The **Great Pacific Garbage Patch**, a swirling mass of plastic debris between California and Hawaii, is just one visible manifestation of a much larger problem. Beneath the surface, microplastics—tiny plastic particles formed from the breakdown of larger plastics—are infiltrating marine habitats, altering ecosystems, and even making their way into human bodies through seafood and drinking water.

Recognizing the urgency of the situation, scientists, engineers, environmentalists, and governments around the world are turning to technology for solutions. From massive ocean-based cleanup systems to smart AI-driven drones and river interceptors, a wave of innovative technologies is now being deployed to address this global crisis. These tools not only aim to remove existing waste but also to prevent further plastic leakage into marine environments.

This article explores the major ocean cleanup technologies currently being developed or deployed, highlighting their design, functionality, success stories, and future potential. We will examine efforts like **The Ocean Cleanup Project**, **autonomous waste-collecting drones**, **river-based trash interceptors**, and **biotechnological solutions** for degrading plastics at a molecular level. Additionally, we will touch upon the integration of **artificial intelligence**, **satellite tracking**, and **circular economy principles** in the global fight against plastic pollution.

The journey to a cleaner ocean is complex and multifaceted. While technology alone cannot solve the plastic crisis, it provides a powerful toolkit when combined with education, policy, and public engagement. Through innovation and collaboration, we can envision a future where oceans are no longer choking on plastic, but thriving once more.

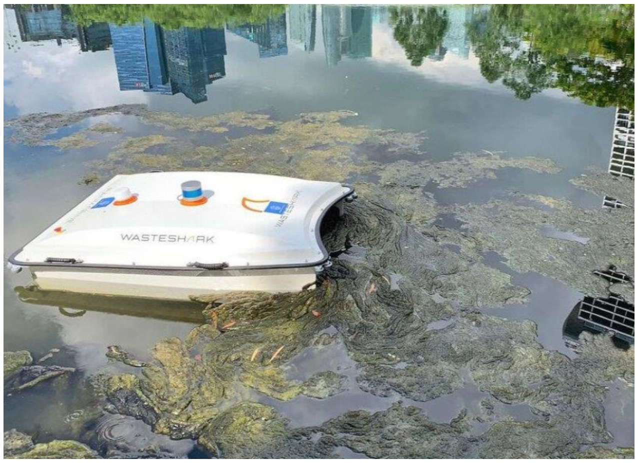
## 2.AUTONOMOUS DRONES AND ROBOTS

As plastic pollution becomes increasingly widespread and complex, traditional cleanup methods—such as manual collection or large-scale trawling—are proving insufficient and often environmentally disruptive. This has led to the rise of **autonomous drones and robots**—innovative, intelligent machines designed to collect plastic waste with minimal human intervention and maximum efficiency. These systems operate in rivers, coastal areas, and open oceans, offering scalable, eco-friendly solutions to one of the planet's most persistent problems.

**1.Waste Shark: The Water Drone Inspired by Nature Waste Shark**, developed by **Ran Marine Technology**, is an aquatic drone modeled after the whale shark—an ocean filter feeder. Roughly the size of a small boat, Waste Shark autonomously roams through harbors, rivers, and lakes, collecting plastic waste and other debris from the surface of the water.

plastic waste and other debris from the surface of the water.

Link: https://youtu.be/mFOi2QsZ3-w?si=w6drs5tgyhWOpJ7Z



- **Collection Capacity**: Up to 200 liters (about 500 kg) of waste per trip.
- **Navigation**: Equipped with GPS and sensors, Waste Shark can be programmed to follow specific routes.
- **Eco-Friendly**: It produces no noise pollution or emissions, making it safe for marine life.
- **Data Collection**: It also collects water quality data like pH, temperature, and turbidity.

Waste Shark is ideal for confined or semi-enclosed water bodies and is already in use in cities such as Dubai and Rotterdam.

---

### 2. Sea Vax: A Solar-Powered Marine Vacuum

**Sea Vax** is a conceptual unmanned vessel designed by **Bluebird Marine Systems**. This solar- and wind-powered drone is designed to travel across oceans, vacuuming up plastic waste from the water column.

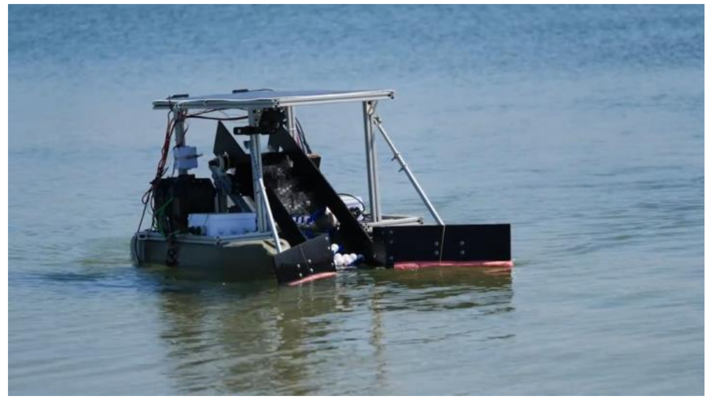
- **Design**: It features a large filtration and storage system that allows it to separate plastic from organic matter.
- **Energy Independence**: Powered by solar panels and wind turbines, it operates without fossil fuels.
- **Capacity**: Potentially up to 22,000 liters of waste in a single journey.
- **Scalability**: Fleets of Sea Vax vessels could work together to clear large patches of ocean debris.

Though Sea Vax is still in the research and development phase, it represents a significant leap toward a non-invasive, sustainable solution to open-ocean plastic pollution.

---

### 3. FRED: Floating Robot for Eliminating Debris

**FRED** (Floating Robot for Eliminating Debris) is an ocean-cleaning robot developed by **Clear Blue Sea**, a nonprofit organization. Still in prototype stages, FRED is envisioned as a small, solar-powered vessel that skims the ocean surface to remove floating plastics.



Meet FRED – Floating Robot to Eliminate Debris

- **Mechanism**: Uses front-mounted collection flaps and a conveyor system to scoop debris into onboard bins.
- **Sensors**: Uses cameras and sonar to detect obstacles and trash.
- **Energy Source**: Runs on renewable solar energy.
- **Deployment Goal**: Designed for deployment in both nearshore and open ocean environments.

FRED is modular and scalable, making it ideal for community-level deployments or integration into larger international cleanup efforts.

---

### 4. Jelly fish bot: Cleaning Confined Waters

Designed by the French company **IADYS**, the **Jelly fish bot** is a compact, remote-controlled robot designed to clean ports, marinas, and other confined water bodies.

- **Size**: Small and highly maneuverable.
- **Applications**: Removes floating debris and oil slicks in tight spaces where larger robots can't operate.
- **Control**: Can be operated remotely or work autonomously.

Its design and ease of use make it a popular choice among local municipalities and private marina operators in Europe.

---

### 5. Robo Sea's Robotic Fish

In China, the company **Robo Sea** has developed a **robotic fish** that mimics the movement of real fish to navigate underwater environments and collect submerged plastic particles.

- **Mimicry**: Designed to swim like a fish, reducing disturbance to aquatic life.
- **Sensors**: Equipped with sonar and cameras for real-time monitoring.
- **Microplastic Potential**: Though currently focused on observation, future versions aim to collect microplastics and underwater waste.

This bio-inspired technology exemplifies how robotics can align with marine ecosystems, offering non-disruptive cleanup options.

---

**Advantages of Autonomous Robots in Ocean Cleanup**

- ✅ **Scalability**: Can be deployed in fleets to cover large areas.
- ✅ **Minimal Human Involvement**: Reduces labor costs and risks in hazardous marine environments.
- ✅ **Eco-Friendly Operation**: Most are powered by renewable energy.
- ✅ **24/7 Operation**: Can work continuously, increasing cleanup efficiency.
- ✅ **Data Integration**: Many robots collect valuable environmental data, aiding broader conservation efforts.

---

**Challenges and Considerations**

Despite their promise, autonomous drones and robots face several challenges:

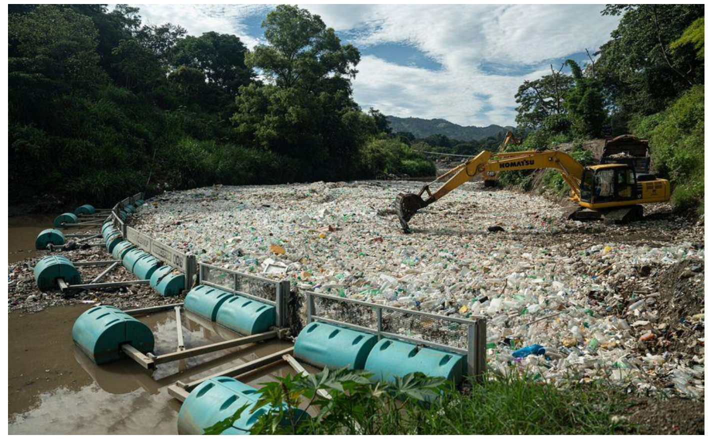
- ⚠ **High Initial Costs**: Development and deployment can be expensive.
- ⚠ **Maintenance**: Devices operating in salty, debris-laden waters need frequent upkeep.
- ⚠ **Navigation Safety**: Risk of collision with boats or marine life.
- ⚠ **Waste Disposal Logistics**: The collected waste still needs to be processed and recycled responsibly

.

## 3.RIVER AND HARBOR INTERCEPTORS: BLOCKING PLASTIC AT THE SOURCE

Rivers are among the most significant contributors to ocean plastic pollution, acting as channels that transport waste from land to sea. It is estimated that over 80% of ocean plastic originates from land-based sources, and a large portion flows through rivers. Targeting these pollution pathways has led to the development of various river and harbor interceptor technologies that are both efficient and cost-effective. One of the most prominent innovations is *The Interceptor*, developed by The Ocean Cleanup.

This solar-powered, autonomous barge is designed to extract plastic waste from rivers before it reaches the ocean. Positioned strategically, it uses guiding barriers to funnel trash into a conveyor system that automatically loads it into onboard dumpsters. It can remove up to 110,000 pounds of waste per day and operates in countries like Indonesia, Malaysia, and Vietnam. Another iconic solution is *Mr. Trash Wheel*, a hybrid-powered (solar and hydro) trash interceptor stationed in Baltimore's Inner Harbor. It features rotating arms and a conveyor belt system that pulls floating trash into dumpsters. Designed with large googly eyes to foster public interest, Mr. Trash Wheel and its companions—Professor Trash Wheel and Captain Trash Wheel—have removed thousands of tons of waste while educating the community. In quieter waters like marinas and



yacht clubs, the *Seabin Project* deploys submerged bins that use pumps to draw in surface water, trapping floating debris and even microplastics, then filtering clean water back out. Each Seabin can collect up to 1.5 kilograms of waste daily and is deployed in over 50 countries. Smaller-scale solutions like *Litter Gitters*—floating traps placed in stormwater outfalls—and floating boom systems are also used in urban waterways to capture trash close to the source. These interceptors offer several advantages: they are preventive, scalable, and more accessible for waste retrieval than deep-sea operations. They also foster public engagement and awareness, as seen with Mr. Trash Wheel's popularity. However, these systems are not without challenges. They can be overwhelmed during heavy rainfall or floods, require regular maintenance, and depend on consistent funding and local government support. Nevertheless, river and harbor interceptors remain a vital first line of defense in the global fight against ocean plastic, combining practical engineering with public participation to make tangible environmental impact.

## 4.MICROPLASTIC REMOVAL INNOVATIONS: TACKLING THE INVISIBLE THREAT

Microplastics—plastic fragments less than 5 millimeters in diameter—represent one of the most insidious forms of ocean pollution. These tiny particles originate from the breakdown of larger plastics or are intentionally manufactured for use in cosmetics, textiles, and industrial processes. Unlike larger debris, microplastics are almost impossible to detect with the naked eye, yet they permeate every level of the marine food chain and have been found in drinking water, seafood, and even human blood. Addressing this invisible threat requires advanced and often delicate technological approaches. One promising solution comes from the **Seabin Project**, which, in addition to capturing floating debris, is capable of filtering out microplastics down to 2 millimeters and surface oils from marinas and calm water bodies. In laboratory and pilot settings, **nanotechnology and electrochemical processes** are also being explored to attract and break down microplastic particles. For instance, **magnetic separation methods** use nanoparticles that bind to microplastics, allowing them to be drawn out of the water using magnets. In another approach, **ultrafiltration membranes** and **reverse osmosis systems** are being developed to capture microplastics from wastewater treatment plants before they reach open waters—this is especially critical, as **35% of primary microplastics come from synthetic textiles released during washing**. Additionally, some biotech firms are experimenting with

**enzymatic degradation**, using specially engineered enzymes or microbes to biologically break down microplastic polymers into harmless components. These innovations are still in early stages, but they offer a potential for large-scale cleanup in the future. A notable ongoing initiative includes the European Union's **Oceans and Plastics Monitoring Project**, which aims to map microplastic hotspots using satellite imaging, AI models, and in-situ sampling devices like **Manta trawls** and **Autonomous Underwater Vehicles (AUVs)**. Despite these efforts, a significant challenge remains in scaling these technologies for open ocean use and ensuring they do not disrupt marine life. Nevertheless, microplastic removal innovations signify a vital leap forward in addressing a form of pollution that is both widespread and dangerously underestimated.

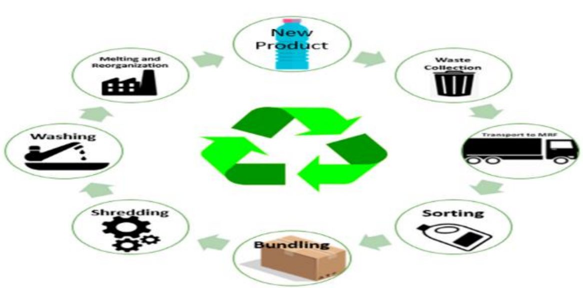
### 5.AI AND SMART MONITORING SYSTEMS

Artificial Intelligence (AI) enhances the efficiency of cleanup operations:itdirection.net

- **AI-Powered Route Optimization**: The Ocean Cleanup has integrated AI algorithms to optimize the paths of plastic-collecting ships, boosting plastic collection efficiency by over 60%. ijoc.informs.org
- **Smart Buoy Networks**: Equipped with sensors and AI, these buoys monitor water quality and pollution levels in real-time, aiding in the rapid identification of pollution hotspots. maevyfinn.com

### 6. BIOTECHNOLOGICAL SOLUTIONS AND CIRCULAR ECONOMY: TRANSFORMING PLASTIC WASTE INTO A SUSTAINABLE RESOURCE

As the world grapples with the escalating crisis of plastic pollution, the spotlight is increasingly turning toward **biotechnology** and **circular economy principles** as long-term, sustainable solutions. Biotechnological innovations focus on **using living organisms or biological processes to break down plastics**, many of which are resistant to natural degradation. A breakthrough came in 2016 when Japanese scientists discovered *Ideonella sakaiensis*, a bacterium capable of degrading PET (polyethylene terephthalate)—a common plastic used in bottles—into harmless byproducts like carbon dioxide and water. Since then, researchers have developed **engineered enzymes**, such as **PETase and MHETase**, that can accelerate the breakdown of PET and other plastics under mild conditions, making recycling more energy-efficient. Another advancement is the use of **fungi and algae** to degrade polyurethane and polystyrene, both of which are notoriously difficult to recycle. While many of these methods are still in the lab phase, they offer revolutionary potential to clean up both terrestrial and marine environments without leaving secondary pollutants behind.




Complementing these efforts is the shift toward a **circular economy**, which aims to design waste out of the system entirely by **reusing, recycling, and upcycling materials**. Unlike the traditional linear model—take, make, dispose—the circular model seeks to **keep plastics in use for as long as possible** through smart product design, reuse systems, and advanced recycling. For example, companies are now investing in **chemical recycling**, which breaks plastics down to their molecular building blocks, enabling the production of virgin-quality materials without new fossil inputs. Simultaneously, the practice of **upcycling** transforms discarded plastic into higher-value products such as clothing, building materials, furniture, and art, adding economic incentive to collection efforts. Notably, brands like Adidas and Parley for the Oceans have created entire fashion lines from upcycled marine plastic, turning pollution into profit and awareness.

These strategies not only reduce the environmental footprint of plastics but also **stimulate green innovation, create jobs**, and shift public perception from plastic as waste to plastic as a resource. According to the **Ellen MacArthur Foundation**, embracing a circular economy could eliminate over **80% of ocean plastic leakage by 2040**, reduce greenhouse gas emissions by **25%**, and create savings of over **$200 billion annually**. When integrated with biotechnological breakthroughs, these approaches can redefine the plastic lifecycle, minimize dependency on virgin materials, and forge a sustainable path toward a plastic-free ocean.

### 7.RESULTS AND FINDINGS: PROGRESS AND PROMISE IN OCEAN PLASTIC CLEANUP

The implementation of ocean cleanup technologies over the past decade has yielded promising results, signaling a growing capacity to combat plastic pollution at multiple levels—from macro-debris to invisible microplastics. One of the most quantifiable successes has come from **The Ocean Cleanup Project**, which has removed over **500,000 kilograms** of plastic waste from the Great Pacific Garbage Patch using its System 002 and 003 technologies. Its river-based solution, *The Interceptor*, has also proven highly effective, collecting thousands of tons of waste annually across some of the world's most polluted rivers, including in Indonesia and Malaysia.

In urban water systems, initiatives like **Mr. Trash Wheel** in Baltimore have intercepted more than **1,500 tons of floating debris** from just one harbor, demonstrating the potential for localized, community-friendly solutions.

The **Seabin Project**, active in over 50 countries, has captured millions of microplastic particles and surface oils from marinas, while raising global awareness about small-scale interventions. Pilot technologies utilizing **magnetic separation**, **ultrafiltration**, and **enzyme-based plastic degradation** have shown laboratory success in targeting microplastics and even breaking down plastic polymers into biodegradable components. Though many of these innovations are in early stages, they provide a foundation for scalable solutions in the future.

On a systemic level, efforts toward a **circular economy** have begun to influence global production and consumption patterns. Major brands and manufacturers are adopting **recycled plastic** and **upcycled marine waste** into their supply chains. The growing investment in **chemical recycling** and bio-based alternatives is reducing reliance on virgin plastic, helping to close the loop in the material lifecycle. According to the **Ellen MacArthur Foundation**, existing technologies—when combined with circular economic principles—could reduce plastic leakage into the ocean by up to **80%** by 2040, while delivering net economic benefits and significant reductions in carbon emissions.

Despite these successes, the results also highlight persistent challenges. Many technologies face **scalability issues**, particularly in regions with weak waste management infrastructure. Others struggle with **seasonal limitations**, maintenance needs, or funding gaps. Additionally, most current systems target surface-level debris, while a large proportion of plastic pollution sinks or breaks down into micro- and nano plastics that remain harder to capture.

## 8.CONCLUSION: GLOBAL SOLUTIONS AND INDIA'S CRUCIAL ROLE IN OCEAN CLEANUP

Plastic pollution in the world's oceans is one of the defining environmental challenges of the 21st century. Every year, millions of tons of plastic waste enter marine ecosystems, harming wildlife, disrupting food chains, and threatening human health. Over the past decade, ocean cleanup technologies have emerged as essential tools to tackle this growing crisis. From river interceptors that prevent plastics from reaching the sea, to ocean systems that collect large floating debris, and advanced innovations targeting microplastics, these technologies provide hope for restoring ocean health. Yet, the global fight against plastic pollution requires a blend of innovation, policy, public engagement, and local action.

Among the many nations confronting the plastic crisis, **India** plays a pivotal role due to its extensive coastline—stretching over 7,500 kilometers—and heavily polluted rivers like the Ganges and Yamuna. Studies show that Indian rivers contribute significantly to the flow of plastics into the ocean. This makes India both a major source of marine plastic pollution and a critical partner in global cleanup efforts. Recognizing this, the country has started deploying various cleanup technologies alongside policy reforms and grassroots activism.

One flagship effort is the **Namami Gange Programme**, which integrates river cleaning with solid waste management to reduce plastic flow into the Ganges. Technologies such as river trash traps and surface skimmers are deployed in urban stretches to capture waste before it reaches the sea. These interventions are vital since rivers act as major conduits funneling plastics into the ocean. Additionally, India has seen growing interest from international groups like **The Ocean Cleanup**, which aims to install their **Interceptor** systems in Indian rivers, marking a strategic collaboration to address riverine pollution at the source.

Complementing large-scale government efforts are vibrant local initiatives and private sector innovations. Indian startups are increasingly embracing the **circular economy** concept—transforming plastic waste into new products, reducing the need for virgin plastics, and creating economic value. Companies like **Ricron Panels** turn multi-layered plastic waste into construction materials, while others focus on efficient recycling and waste-to-energy solutions. Moreover, community-driven movements, inspired by activists such as **Afroz Shah**, who led the monumental **Versova Beach cleanup** in Mumbai, exemplify how citizen participation can amplify technology's impact. These local actions build awareness, encourage responsible behavior, and demonstrate the power of collective effort.

The global ocean cleanup movement has also seen advances in tackling **microplastic pollution**, which poses a unique challenge due to its small size and widespread presence. Indian researchers and technology firms are exploring filtration systems and enzymatic degradation methods, hoping to integrate these with municipal wastewater treatment to stop microplastics before they enter waterways. The combination of traditional cleanup devices and cutting-edge biotechnology holds great promise, but requires sustained investment and research.

On the policy front, India has updated its **Plastic Waste Management Rules** to include extended producer responsibility (EPR), requiring manufacturers to take accountability for their plastic footprint. Such regulations, if rigorously enforced alongside improved waste collection and recycling infrastructure, can drastically reduce plastic leakage into oceans. Still, the effectiveness of cleanup technologies depends on this supportive regulatory and societal framework.

Despite the many successes, challenges remain. Many cleanup technologies struggle to scale up in regions with limited infrastructure or face operational difficulties during monsoon floods and extreme weather. Deep ocean and microplastic pollution remain particularly hard to address. Additionally, funding constraints and the need for widespread behavioral change pose ongoing hurdles.

Yet, the overall results are encouraging. Globally, ocean cleanup technologies have removed hundreds of thousands of kilograms of plastic debris from rivers, harbors, and open waters. India's growing role in this ecosystem—through technological adoption, policy reform, and community activism—demonstrates the potential of local actions to feed into a global solution. According to international estimates, widespread deployment of these technologies combined with a circular economy approach could reduce plastic leakage into the ocean by over **80% by 2040**, while also lowering carbon emissions and fostering economic growth.

In conclusion, the fight against ocean plastic pollution is a shared responsibility requiring coordinated action at all levels—global, national, and local. India's unique geographical challenges and vibrant innovation ecosystem position it to be a leader in this movement. Ocean cleanup technologies are not a standalone fix but an indispensable part of a larger strategy that includes reducing plastic production, improving waste management, enforcing regulations, and shifting cultural attitudes toward sustainability.

As these efforts accelerate, they offer hope that we can restore the health and resilience of our oceans. With continued innovation, investment, and collective will, we have the tools to safeguard marine ecosystems for future generations. The ocean, vast and life-giving, can once again be a thriving, plastic-free sanctuary—if we act decisively and together.

---

### APPENDIX A: PLASTIC WASTE STATISTICS

| Category | Data |
|---|---|
| **Estimated plastic entering oceans yearly** | ~11 million metric tons (UNEP, 2021) |
| **% of ocean plastics from rivers** | ~80% of marine plastics come from land-based sources |
| **Top 10 plastic-polluting rivers** | Ganges (India), Yangtze, Indus, Mekong, etc. |
| **India's annual plastic waste generation** | ~3.5 million metric tons (CPCB, 2022) |
| **Plastics collected by The Ocean Cleanup (2023)** | Over 200,000 kg from Great Pacific Garbage Patch |
| **Plastics removed by Mr. Trash Wheel (2022)** | Over 1,200 tons from Baltimore waterways |

### APPENDIX B: RELEVANT GOVERNMENT AND NGO INITIATIVES IN INDIA

| Initiative/Organization | Description |
|---|---|
| **Namami Gange Programme** | Government-led river cleaning project focused on pollution control, including plastics. |
| **Swachh Bharat Mission** | National sanitation campaign with plastic waste reduction goals. |
| **Afroz Shah Foundation** | NGO driving massive beach and coastal cleanups in Mumbai. |
| **CPCB – Plastic Waste Management Rules** | Legal framework for controlling plastic production and disposal. |
| **UNDP India Plastic Waste Mgmt Project** | Works with municipalities and informal sector for plastic waste reduction. |

### ACKNOWLEDGMENTS

**I would like to extend my sincere gratitude to all the individuals, organizations, and institutions whose efforts and insights have contributed to the completion of this article.**

**Special thanks to The Ocean Cleanup Foundation, Seabin Project, and Mr. Trash Wheel initiative for pioneering innovative solutions and making valuable data publicly accessible. Their technological leadership in the field of ocean and river cleanup provided a strong foundation for this research.**

**I am grateful to environmental agencies and NGOs in India, including the Ministry of Environment, Forest and Climate Change (MoEFCC), Central Pollution Control Board (CPCB), and the Afroz Shah Foundation, whose work on the ground has highlighted the importance of local action in tackling plastic pollution.**

**Finally, I would like to thank all environmental activists, volunteers, educators, and innovators who are working tirelessly—often behind the scenes—to keep our rivers, oceans, and communities clean. Their dedication inspires the belief that with collaboration, creativity, and commitment, a plastic-free future is possible.**

### 9. REFERENCES

1. **The Ocean Cleanup.** (2024). *The mission to rid the world's oceans of plastic.* Retrieved from https://theoceancleanup.com
2. **UNEP – United Nations Environment Programme.** (2021). *From pollution to solution: A global assessment of marine litter and plastic pollution.* Retrieved from

https://www.unep.org/resources/pollution-solution
3. **Ellen MacArthur Foundation.** (2020). *The New Plastics Economy: Catalyzing action*. Retrieved from https://www.ellenmacarthurfoundation.org
4. **National Geographic.** (2020). *The world's rivers are polluting the oceans*. Retrieved from https://www.nationalgeographic.com/environment/article/ocean-plastic-pollution-solutions
5. **World Economic Forum.** (2022). *India is tackling plastic pollution with these innovations*. Retrieved from https://www.weforum.org
6. **CPCB – Central Pollution Control Board, India.** (2022). *Annual Report on Plastic Waste Management*. Retrieved from https://cpcb.nic.in
7. **Banyan Nation.** (2023) https://banyannation.com
8. **Krause, S., et al.** (2022). *Technologies for marine litter removal: A review. Marine Pollution Bulletin*.
9. **Jambeck, J. R., et al.** (2015). *Plastic waste inputs from land into the ocean*.
10. **WWF India.** (2021). *Plastic pollution in India's rivers and its threat to marine life*. Retrieved from https://www.wwfindia.org
11. **Seabin Project.** (2024). *Removing marine litter from ports and marinas worldwide*. Retrieved from https://seabinproject.com
12. **Mr. Trash Wheel.** (2024). *Baltimore's trash-intercepting water wheel*. Retrieved from https://www.mrtrashwheel.com
13. **The Hindu.** (2022). *India's fight against plastic waste: Cleanup tech and citizen power*. Retrieved from https://www.thehindu.com

## 10.AUTHORS

**First Author – P.K. Arya, M.Sc.(Chemistry),** B.Ed. ,Buddha degree college, Gida @: pinku2520@bdc.ac.in

**Second Author – Rashi, B.Sc.(Biology),** Buddha Degree College, GIDA. @: bdc22bscb21.ac.in