BACTERIA AGAINST PLASTIC: ENVIRONMENT

NEWS: *The promises and problems of using bacteria to get rid of plastic*

WHAT'S IN THE NEWS?

Scientists are developing bacteria, enzymes, and spore-based thermoplastics to tackle plastic waste, offering promising alternatives to traditional disposal methods. However, large-scale industrial adoption faces challenges in efficiency, cost, and regulatory approvals.

1. The Growing Plastic Waste Problem

- **Persistent & Ubiquitous Pollution:**
  - Plastics take **centuries to degrade**, accumulating in landfills, oceans, and ecosystems.
  - **Microplastics contaminate** food chains, water bodies, and even human tissues.
- **Scale of the Crisis:**
  - Since the 1950s, **8.3 billion tonnes** of plastic have been produced.
  - Around **4.9 billion tonnes remain in the environment** due to poor recycling and slow degradation.
  - **Recycling rates remain below 10%**, making alternative degradation methods crucial.

2. Enzyme-Based Plastic Degradation: Breakthroughs & Challenges

Discovery of Plastic-Degrading Enzymes

- **Key Enzyme: IsPETase** (2016, Japan)
  - Found in *Ideonella sakaiensis* bacteria, breaks **PET (Polyethylene Terephthalate)** into monomers.
  - **Limitations:** Naturally slow process, requiring modifications for efficiency.
- **Enzyme Engineering: Faster PET Breakdown**
  - Scientists improved **IsPETase** to degrade **90% of PET within 17 hours**.
  - Produces **reusable monomers** (terephthalic acid and ethylene glycol).

Challenges in Enzyme-Based Degradation

- **Scalability Issues:**
  - Large-scale enzyme production is costly.
  - Requires optimal conditions (temperature, pH) for high efficiency.
- **Industrial Feasibility:**
  - Need to integrate enzyme degradation into **existing plastic waste management** systems.

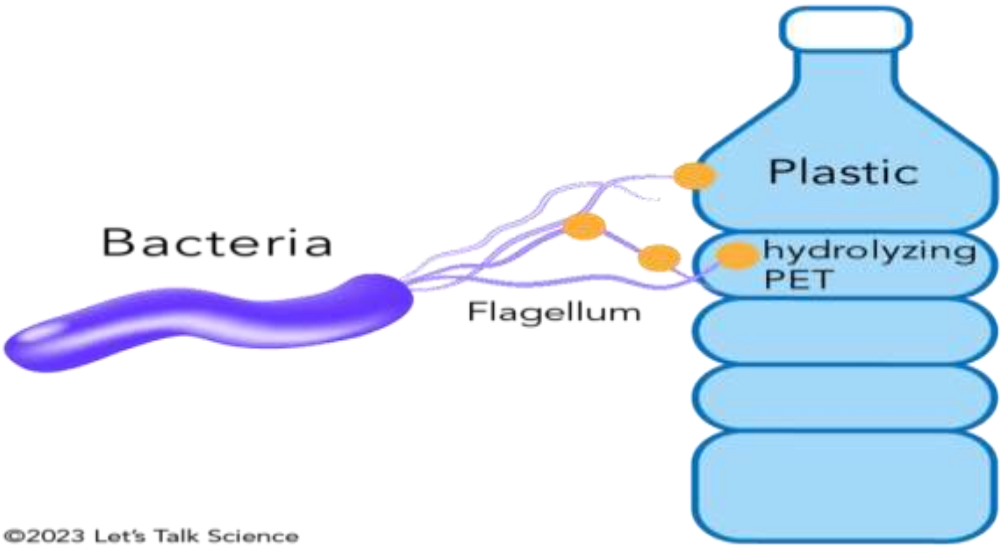
3. Microbial Plastic Degradation: Bacteria as Natural Recyclers

How Bacteria Break Down Plastics

- **Plastic as a Carbon Source:**
  - Some bacteria metabolize plastics into **CO_2, water, and biomass**.
  - Example: **Bacterium X-32** can degrade plastic in **~22 months**.
- **Microbial Degradation Process:**
  1. **Microbes attach to plastic surfaces** and form biofilms.
  2. **Enzymes break down polymer chains** into smaller molecules.
  3. **Microbes metabolize** these molecules for energy.

Challenges in Microbial Plastic Degradation

- **Slow Degradation Rate:**
  - Natural breakdown takes months to years.
  - Requires genetic modification to enhance speed.
- **Environmental Conditions:**
  - Bacterial activity depends on **temperature, oxygen levels, and moisture**.



4. Spore-Based Biodegradable Plastics: A Smart Alternative

Innovation by Harvard & Wyss Institute

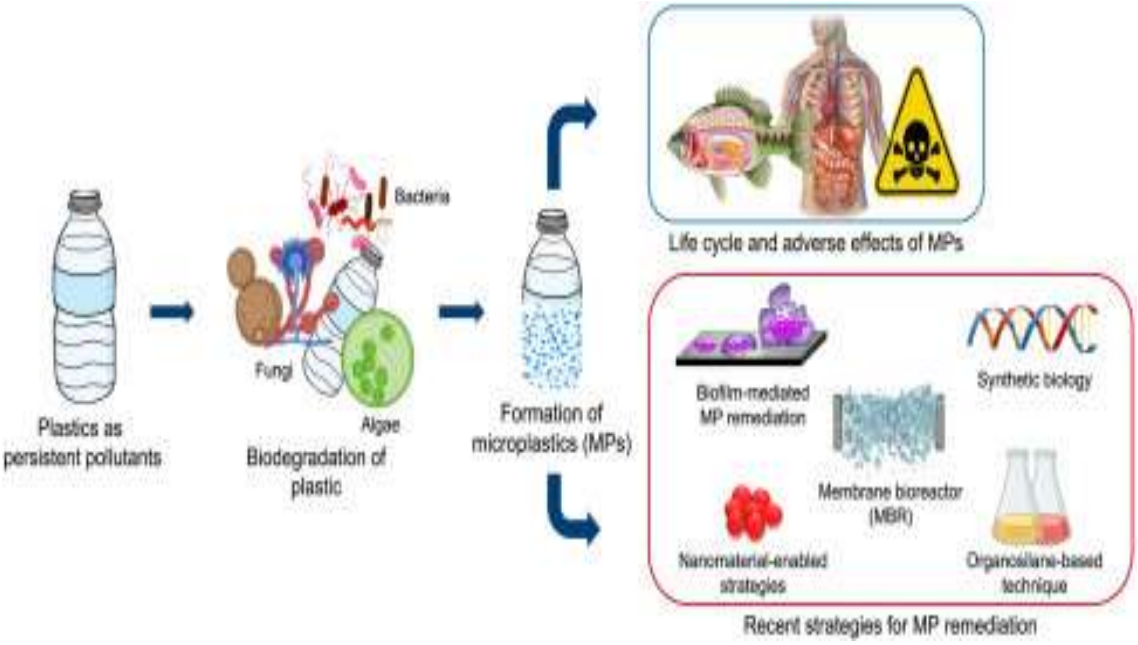
- **Bacillus subtilis spores embedded in plastics** enhance durability and degradation.
- **Mechanism:**
  - Spores remain **dormant under normal conditions**.
  - In composting environments, they **activate and accelerate breakdown**.

Advantages & Challenges

- **Advantages:**
  - Reinforces plastic strength during usage.
  - Biodegrades efficiently in compost.
- **Challenges:**
  - Regulatory hurdles for food/consumer products.

- Cost of spore purification and scaling.

5. Industrial Adoption: Companies Leading the Way



Prominent Innovations

- **Carbios (France):** Developed an **engineered enzyme** breaking PET plastics in **10 hours**.
- **North Carolina Biomaterials Firms:** Testing **spore-based thermoplastics** for commercial applications.

Challenges in Large-Scale Implementation

- **Efficiency vs. Cost:** Need for high degradation speed with minimal costs.
- **Industry Reluctance:** Businesses need financial incentives to shift from traditional plastic production.

6. The Road Ahead: Future Directions & Policy Support

Enhancing Enzymatic & Microbial Efficiency

- Genetic engineering to create **high-speed, cost-effective plastic-degrading bacteria**.
- Combining **enzymatic and microbial approaches** for maximum efficiency.

Government & Industry Collaboration

- **Policy Incentives:**
  - Tax breaks for biodegradable plastic manufacturers.
  - Bans/restrictions on non-recyclable plastics.
- **Investment in R&D:**
  - Funding large-scale trials for enzyme-based solutions.

Source: https://www.thehindu.com/sci-tech/science/the-promises-and-problems-of-using-bacteria-to-get-rid-of-plastic/article69175500.ece