Save Our Waters
OPTIMIZING MICROPLASTIC FILTRATION

Saving Our Waters

One filter at a time…

An analysis of micro and nano plastic removal from water using naturally found materials with magnetic nanoparticle enhancement.

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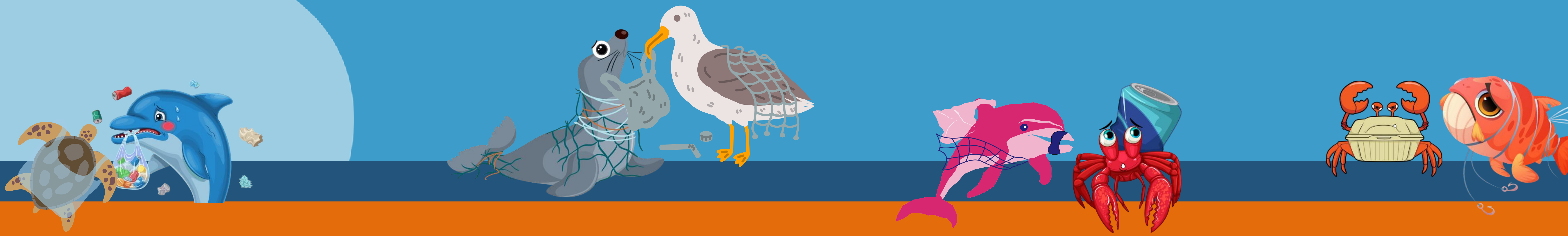


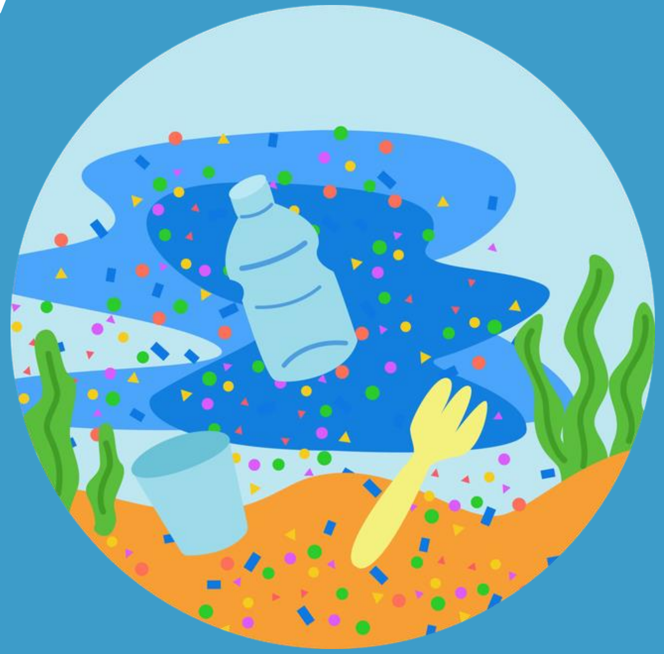
What Are Plastics?

- Plastics are synthetic (man-made) materials made mainly from polymers, which are long chains of molecules, usually produced from petroleum or natural gas.
- Because their structure can be changed during manufacturing, plastics can be made flexible, rigid, transparent, lightweight, or extremely strong.
- They are cost-effective and used in medical equipment, food packaging, transportation, electronics, clothing, and even in clean water systems.
- However, their widespread use has a hidden cost: over time, discarded plastics break down into tiny fragments called micro and nano plastics, which pollute our rivers, lakes, and oceans, posing serious risks to wildlife and human health.

Plastics are not the enemy. They are essential to modern life because they are lightweight, durable, affordable, and lifesaving in the medical and food industries. The real challenge is managing plastic waste responsibly.

What Are Micro and Nano plastics?

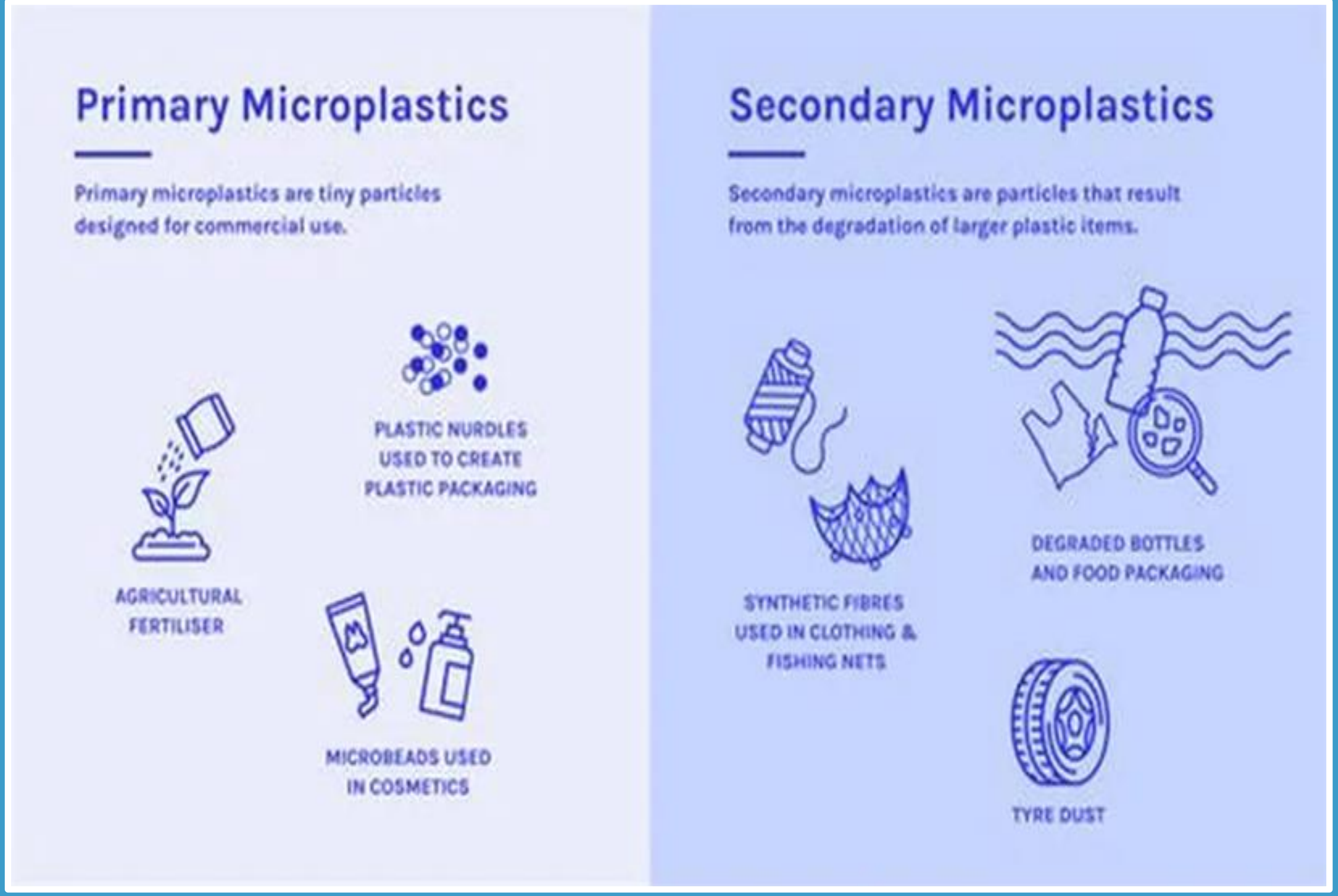
- **Micro and nano plastics are tiny pieces of plastic - usually smaller than 5 millimeters and sometimes even invisible to the naked eye. Microplastics are plastic particles smaller than 5 millimeters, while nano plastics are even smaller, measuring less than 1 micrometer.**
- They originate from both the breakdown of larger plastic items or the direct release of small plastic particles from consumer products and industrial processes.
- They end up in rivers, lakes, and oceans. They can travel long distances and spread across the planet.
- They pose significant threat to our environment and ecosystem. They harm fish, birds, and other wildlife, and may even enter the food chain, eventually reaching humans.

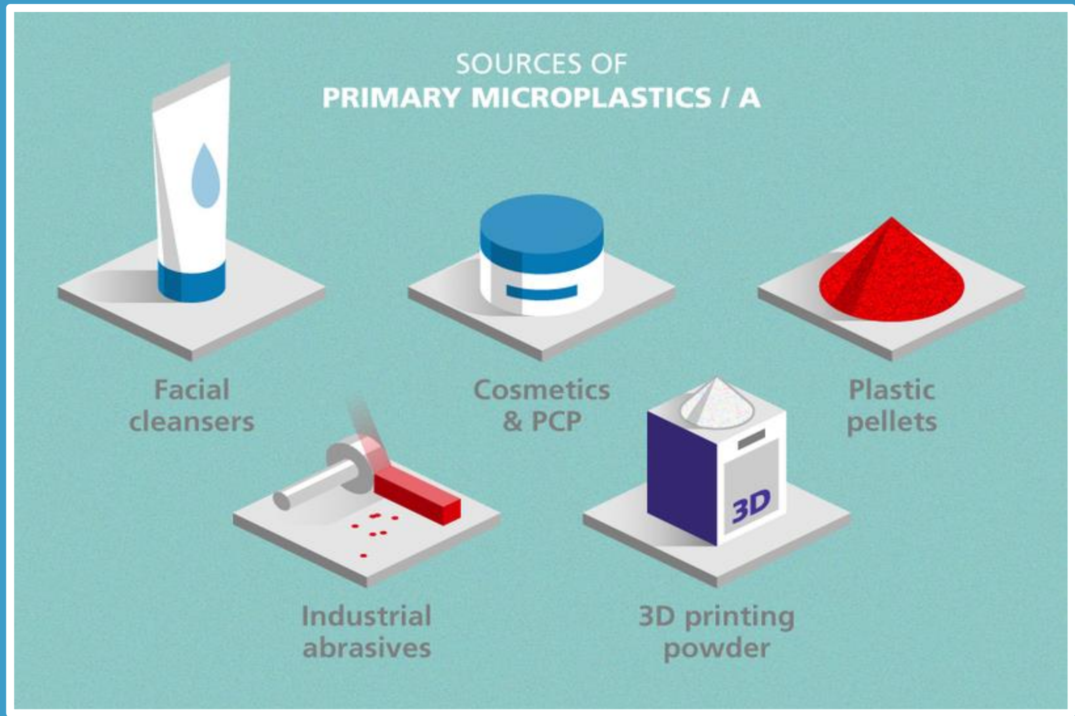


Types of Micro and Nano plastics

Primary Micro and Nano plastics

- Primary microplastics are small plastic particles intentionally manufactured to be microscopic.
- They are found in:
    - Toothpastes, or soaps that contain tiny plastic beads.
    - Industrial plastic pellets (nurdles)
    - Fibers from synthetic textiles
    - Polyester, acrylic, and nylon, which are released during washing.

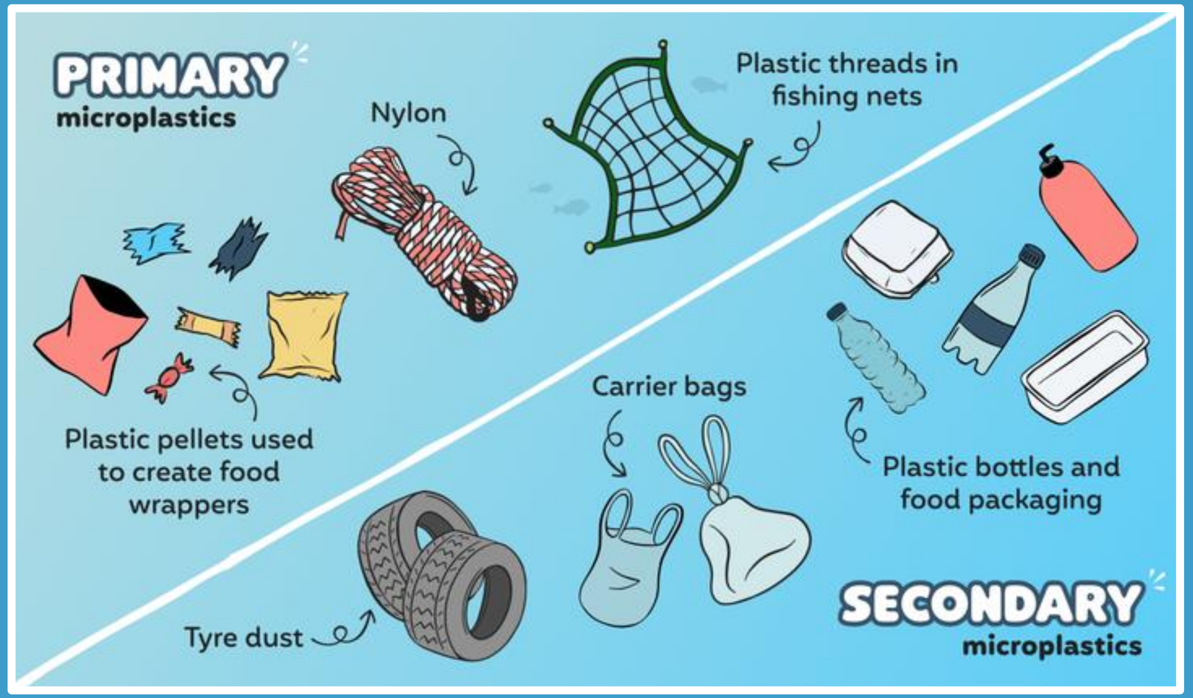




Types of Micro and Nano plastics

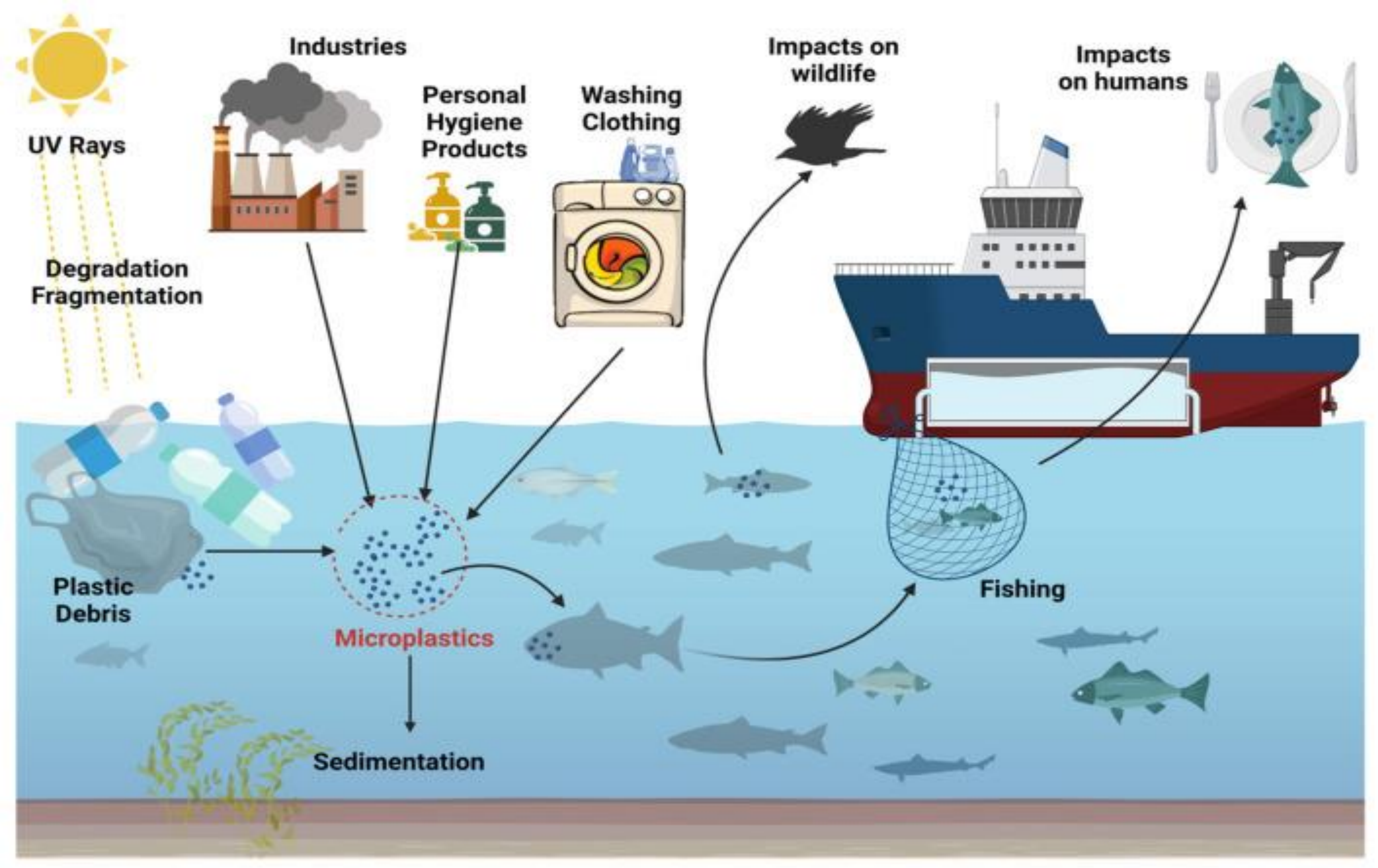
Secondary Micro and Nano plastics

- Secondary Micro and Nano plastics are from the degradation of larger plastic items through mechanical, chemical, or environmental processes.
  - Broken-down plastic items
    - Bottles, bags, fishing gear (like nets, ropes and cages), packaging, and other plastic trash slowly break apart into tiny pieces in water and soil.
  - Synthetic fabrics
    - Polyester, nylon, and fleece release tiny fibres when clothes are washed.
  - Construction and renovation:
    - Materials used in construction and renovation can also contribute to microplastics in the environment
  - Tire wear particles
  - Vehicles, which contribute to road dust and urban runoff.
  - Everyday items such as Toothbrushes, tea bags etc.



Impacts of Micro and nano plastics

- Micro and nano plastics pose significant threats to ecosystems, wildlife, and human health, disrupting food chains and contributing to pollution across various environments.



Impacts of Micro and Nano plastic

- **Aquatic Ecosystem Disruption**

Micro and nano plastics impact marine life through ingestion, entanglement, and habitat disruption. They are readily ingested by a wide range of aquatic organisms, including zooplankton, fish, and marine mammals. These particles can accumulate in animals' digestive tracts, leading to physical blockages, reduced feeding efficiency, and false fullness, ultimately impacting their growth, reproduction, and survival.

- **Terrestrial Ecosystem Disruption**

Micro and nano plastics are readily ingested by land animals and organisms, such as earthworms and insects. They can ingest microplastics in soil, leading to effects like those observed in aquatic organisms, such as reduced feeding rates, altered gut microbiomes, and decreased growth.

- **Soil and Water Contamination**

Micro and nano plastics are found in high concentrations in agricultural soils and coastal waters. They can enter soil through fertilizers made from sewage sludge, plastic used in farming, and tiny plastic particles carried by the wind. These particles can alter soil properties, such as water retention, aeration, and nutrient cycling, affecting plant growth and soil biodiversity. Microplastics can also move into groundwater and rivers, polluting drinking water and harming both land and water ecosystems.

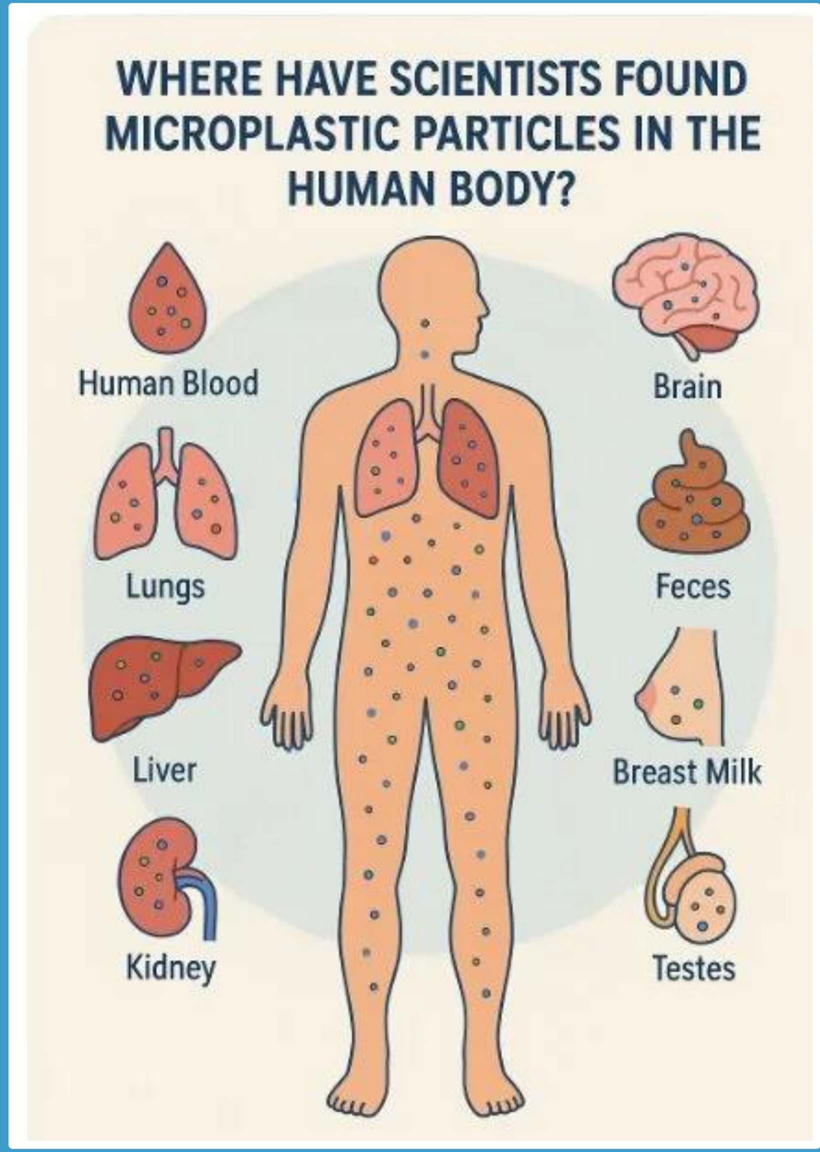
Impacts of Micro and Nano plastic

- **Human Health Risks**

Micro and nano plastics have been detected in various human organs, including the placenta of newborns. They can enter the human body through ingestion, inhalation, and skin absorption, potentially leading to serious health issues, including hormonal disruptions and genetic changes. The long-term health impacts of microplastics are still being studied, but they are associated with various health risks, particularly for vulnerable populations.

- **Contribution to Climate Change**

Micro and nano plastics worsen climate change both directly (from production and breakdown) and indirectly (by harming ocean life that helps absorb CO_2). The production and degradation of plastics contribute to greenhouse gas emissions. When plastics break down in sunlight or in water, they can release small amounts of greenhouse gases like methane and ethylene, which warm the planet. Additionally, improper disposal of plastic waste leads to methane emissions from landfills, further contributing to global warming. Furthermore, Microplastics can harm tiny ocean organisms that help absorb carbon dioxide, reducing the ocean's ability to store carbon and worsening climate change.



Micro and Nano plastic Cleanup Methods

Physical and Filtration Methods

Filtration is one of the most widely used approaches. Conventional wastewater treatment plants employ primary, secondary , and tertiary stages to remove microplastics, achieving 57% to over 99% removal depending on the technology used.

Chemical and Coagulation Methods

Coagulation and flocculation use chemical or plant-based flocculants (e.g., okra, fenugreek) to aggregate microplastic particles, making them easier to remove through sedimentation or filtration. Advanced oxidation process es can degrade certain microplastics

Biological Methods

Bioremediation leverages microorganisms and enzymes to degrade plastics into less harmful substances. For example, PETase enzymes and plastic-eating bacteria can break down microplastics in controlled environments.

Nano-Based and Emerging Techniques

Nanotechnology offers innovative solutions for micro and nanoplastic removal. These nano-enabled methods are promising due to their high specificity, scalability potential, and ability to target nanoscale plastics, which are difficult to remove with conventional methods.

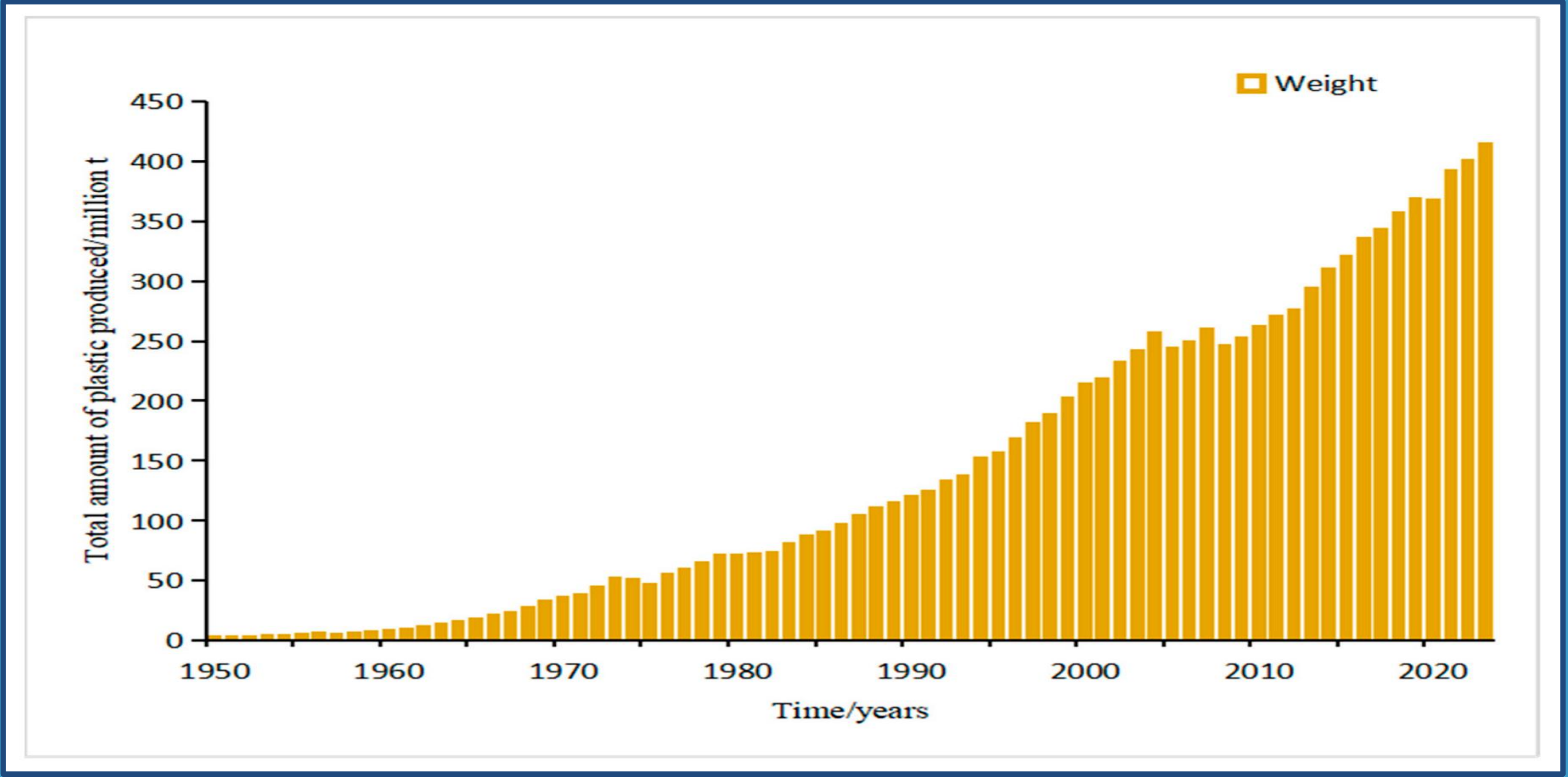
Statistics - Why does this matter to me?

A 2024 study using a measurement method capable of detecting extremely small plastic particles found between 110,000 and 370,000 particles per liter of bottled water — 90% of these particles were nano plastics.

Microplastics indoors can be 60 times higher than those outdoors
The average person globally breathes 2,000 to 7,000 microplastics per day.
An average person will consume an estimated 13,731 to 68,415 microplastic particles that fall onto food during a meal.
Microplastics have been found in human placenta and human feces.

340,000 microplastics per cubic foot of ice were found in the Arctic Ocean.
Microplastics have been found at the top of Mount Everest and at the bottom of the Mariana Trench .

Microplastics Statistics (2024): Consumption & Pollution Data



The annual worldwide production of plastics from 1950 to 2020

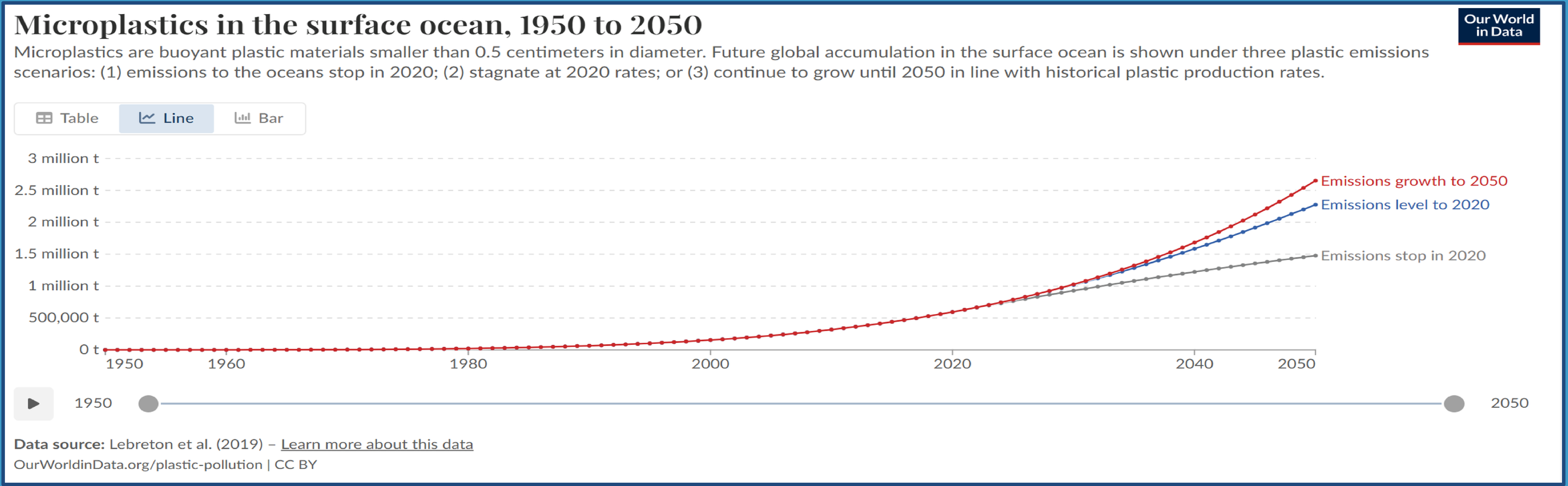
Statistics - Why does this matter to me?

A detailed study in 2021 analyzed data from over 170,000 fish, discovering that microplastics were present in two-thirds of the species examined..

There are approximately 24 trillion pieces of microplastics floating on the ocean's surface.

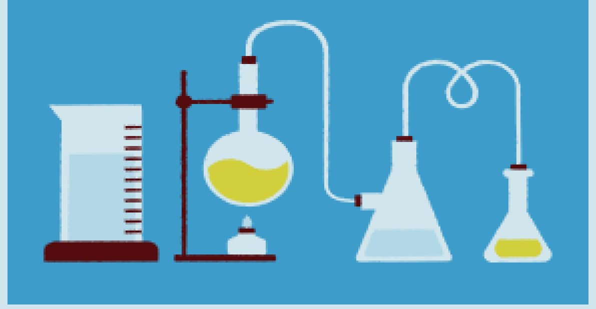
One study in China found that in one pound of soil, 18,000 microplastics could be found.

Microplastics Statistics (2024): Consumption & Pollution Data



Microplastics in the surface ocean, 1950 to 2050

Project Objective



Explore how daily and natural materials can be used to clean micro and nano plastics

Build a filtration system using effective materials.

Project Hypothesis

I hypothesize that

- Nanoparticles will be the most effective method for removing micro- and nano plastics from water because their small size allows them to capture tiny plastic particles that other materials cannot.

- By building a layered filtration system, I expect to separate plastics of different sizes efficiently and produce cleaner water compared to using traditional materials alone.

Materials

- Microplastic Simulation
  - Glitter
  - Grated plastic bottle pieces
  - Straw piece
  - Water
- Filtration Materials
  - Sand
  - Activated charcoal
  - Cotton pad
  - Coconut coir
  - Pebbles

- Magnetic Test
  - Steel wool
  - Iron fillings (small amount)
  - Magnets

- Filter System
  - Bottle

- Others
  - Measuring cup
  - Mixing spoon

Variables

Independent Variable (What you change)

- Filtration material (Sand, Activated Charcoal, Pebbles, Nano particles etc)
- Use of magnetic particles (Steel wool, ferro fluid etc)

Dependent Variable (What you measure)

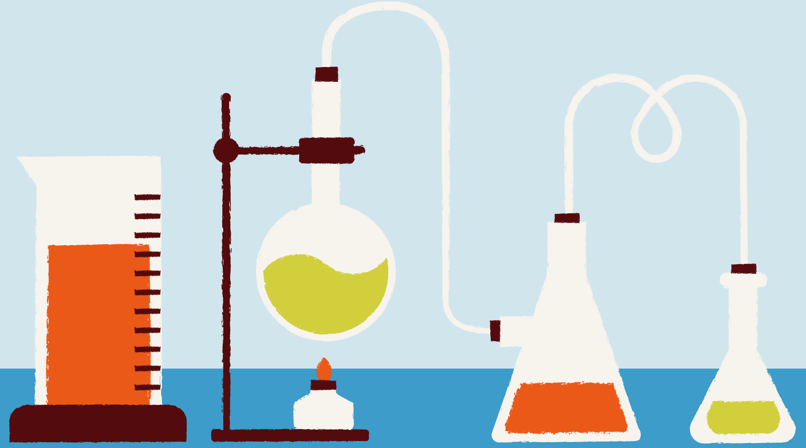
- Microplastics Removed (%)
- Water Clarity
- Filtration Time (s)

Controlled Variables (What you keep the same)

- Amount of water = 1/4 cup
- Amount of microplastics added = 1 tsp each of glitter, plastic and steel wool
- Container size
- Stirring method

Methodology

Step-by-step procedure for the project:



Step 1

Create a filter with plastic cups

Step 2

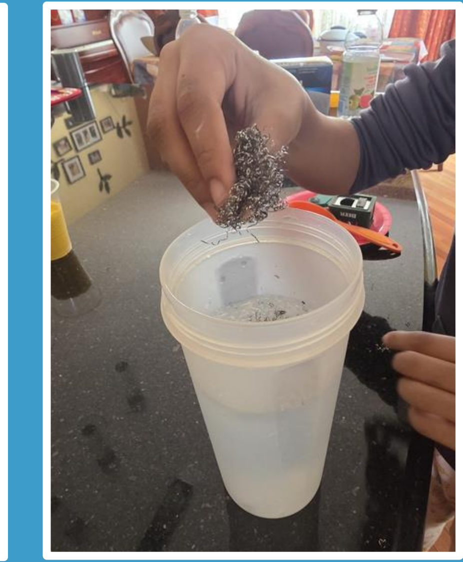
Prepare the materials for testing

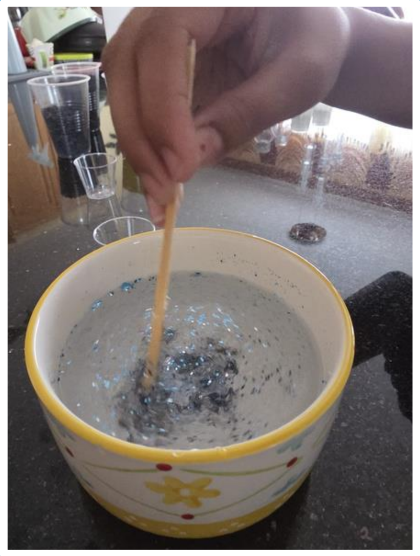
Step 3

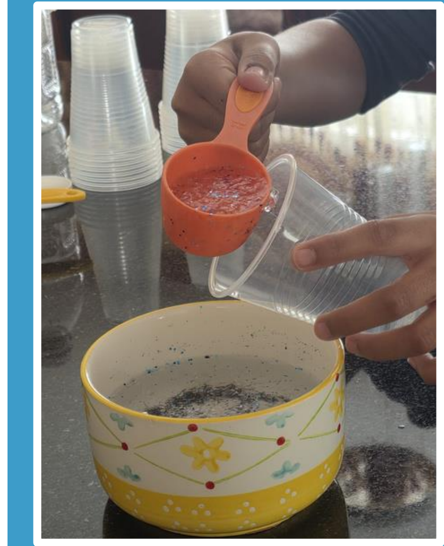
Prepare the filter materials

Step 4

Prep the water with microplastic simulation







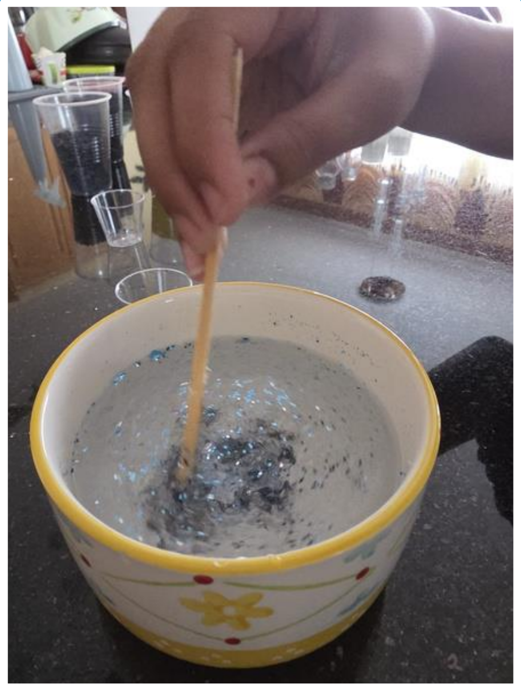
Procedure - Preparation

Filters

- Made tiny holes in the bottom of the cups
- Labelled the cups
- Placed them on top of smaller cups to collect water

Micro and nano plastic simulated water

- Collected water in a large cup
- Mix in glitter (simulates very small microplastics that float in water)
- Cut straws and plastic bottles into small pieces and mix them in (simulates larger fragments of plastic)
- Added steel wool (simulating magnetic effect)
- Added Ferrofluid (simulating nano tech effect)
- Collected ¼ cup of these for the experiments



Procedure - Filter 1 – Sand

Physical and Filtration Methods

Process

- Placed sand at the bottom of the cup
- Pour the microplastic simulated water through the cup with sand
- Collected and observed the water
- Repeated the process at least 3 times.

Observation

- Coarse sand allows faster flow; fine sand increases filtration efficiency
- While this is an effective, low-cost physical filter for trapping small particles, its effectiveness depends on grain size, packing, and particle size of the microplastics.

Pros	Challenges
Sand is inexpensive and easily available.	Very small particles passed through.
Naturally occurring	Fine sand can slow water flow when packed too tightly.
Environmentally safe	Must be cleaned or replaced after repeated use.
	Sand cannot remove chemicals or dissolved toxins.
	Adds weight to the filtration system Only filters them — does not degrade or remove them

Procedure - Filter 2 - Pebbles

Physical and Filtration Methods

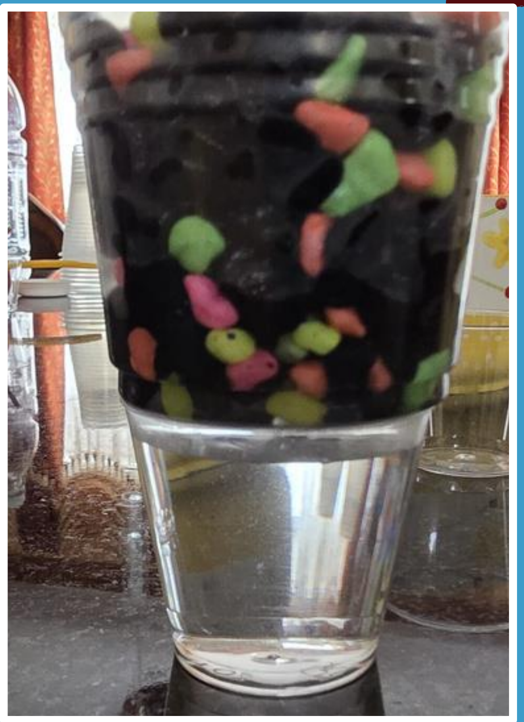
Process

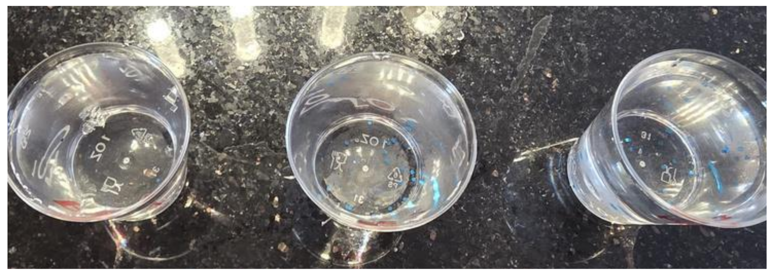
•Placed pebbles at the bottom of the cup
•Pour the microplastic simulated water through the cup with pebbles
•Collected and observed the water
•Repeated the process at least 3 times.

Observation

Pebbles provide strong support and improve water flow in a filtration system, but they do not directly remove microplastics and mainly trap only large debris.

Pros	Challenges
Pebbles are inexpensive and easily available.	Pebbles are too large to filter small particles.
Naturally occurring	Reduces space for finer filtration materials
Environmentally safe	Acts more as a support layer than a filtering layer.
Keeps upper filter layers (sand, charcoal, cotton) from washing out.	Adds weight to the filtration system.
Can be washed and reused multiple times	





Procedure - Filter 3 - Activated Charcoal

Physical and Filtration Methods

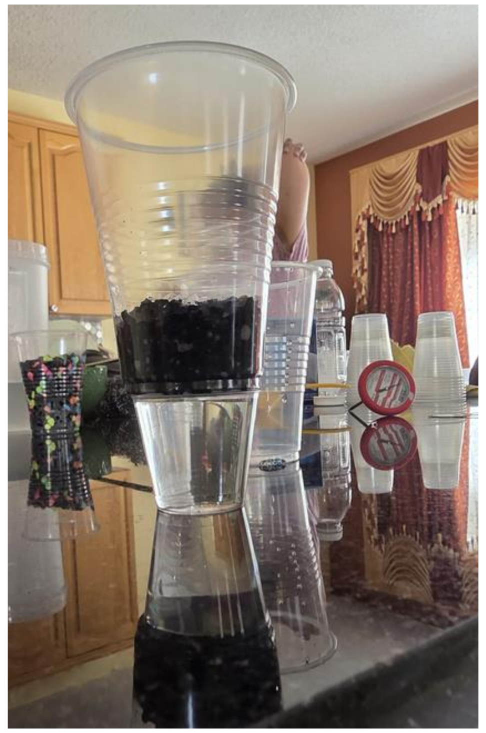
Process

- Placed activated charcoal at the bottom of the cup
- Pour the microplastic simulated water through the cup with activated charcoal
- Collected and observed the water
- Repeated the process at least 3 times.

Observation

Activated charcoal effectively traps small particles and possibly can trap chemicals, but cannot remove microbes and needs frequent replacement

Pros	Challenges
Made from natural materials	Water passes slowly due to fine pores.
Traps small particles, possibly chemicals, and impurities	Powder form can mix into water if not contained.
Could further remove color, odor, and some contaminants	Cannot be reused indefinitely without cleaning
Works well with additional filters	



Procedure - Filter 4 - Coconut Coir/Fiber

Physical and Filtration Methods

Process

•Placed coir at the bottom of the cup
•Pour the microplastic simulated water through the cup with coir
•Collected and observed the water
•Repeated the process at least 3 times.

Observation

Coconut fiber is useful for trapping microplastics and supporting filtration layers, but cannot remove chemicals and saturates quickly
The water was really contaminated, and this wasn't effective at all

Pros	Challenges
Environmentally safe	Cannot remove chemicals or toxins like activated charcoal
Can catch microplastics, sediments, and debris	Water passes slowly
Lightweight & Flexible	Breaks down faster than pebbles or sand
	By itself, fibers can float into water

Procedure - Filter 5 - Cotton

Physical and Filtration Methods

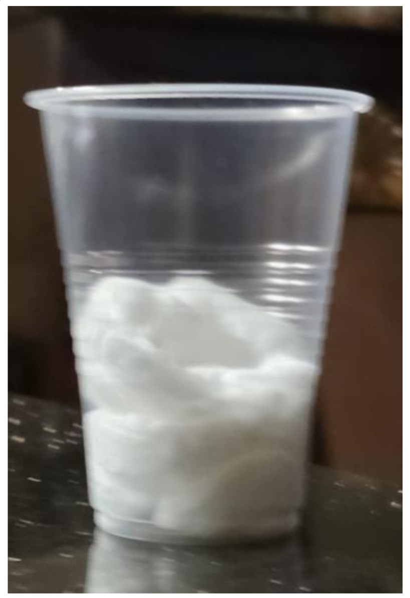
Process

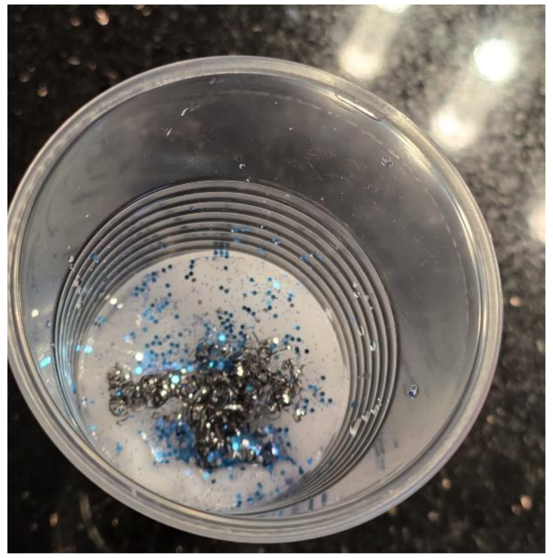
- Placed cotton at the bottom of the cup
- Pour the microplastic simulated water through the cup with cotton
- Collected and observed the water
- Repeated the process at least 3 times.

Observation

Cotton is a simple and effective layer for physically trapping microplastics and supporting filtration, but it cannot remove chemicals and clogs relatively quickly.

Pros	Challenges
Can catch sediments and microplastics effectively	Ineffective for dissolved toxins or impurities
Can be layered, folded, or shaped to fit the filter	Becomes less effective when clogged with particles
Lightweight & Flexible	Dense layers can reduce water flow
Eco-friendly and safe for experiments	Wears out faster than sand or pebbles
	Drastically reduces water quantity






Procedure - Filter 6 – Steel Wool

Magnetic Separation

Process

- Mixed simulated water with steel wool
- Placed a magnet on the side of the cup
- Observed the water
- Repeated the process at least 4 times.

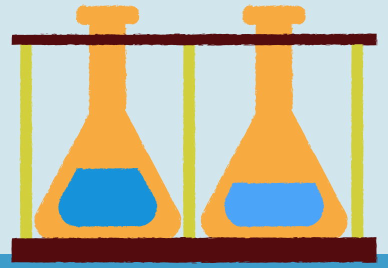
Observation

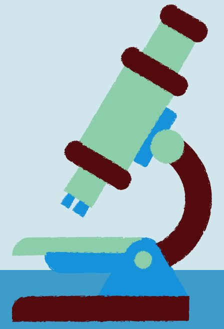
Steel wool and magnets are excellent for quickly removing metallic debris. This can help us isolate the particle, too, but it cannot capture pure plastics or chemical contaminants and requires careful handling.

Pros	Challenges
Magnets attract ferrous (iron-containing) microplastics or debris	Not very effective for just plastic based debris
Can be cleaned and reused multiple times and last through multiple filtration cycles	Steel wool/ iron fillings can rust
Works well as a complementary layer in combination with other filter materials.	Fibers can break off and contaminate water
Magnet attracts particles almost immediately	By itself, fibers can float into water

Procedure - Filter 7 –Ferrofluid

Magnetic Separation





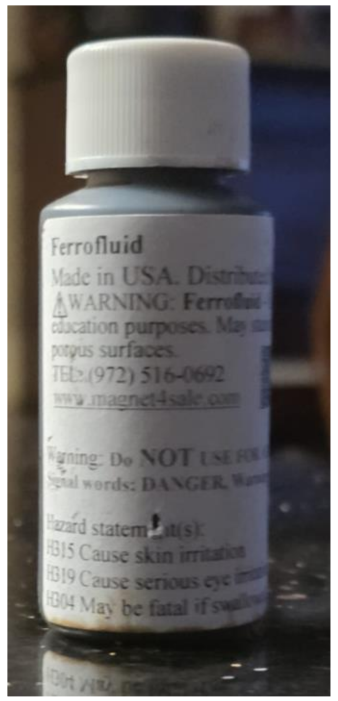
Process

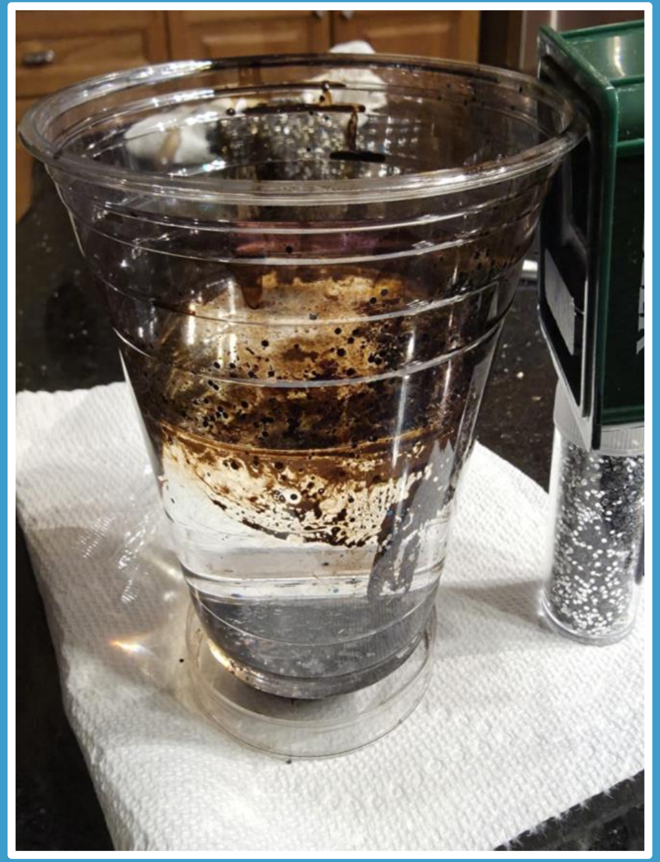
•Mixed simulated water with ferrofluid, containing iron fillings
•Placed a magnet on the side and bottom of the cup
•Observed the water
•Repeated the process at least 4 times.

Observation

Ferrofluid shows outstanding promise in capturing and separating various levels of microplastics and oil efficiently, with fast, reusable, and visually impressive results

Pros	Challenges
Magnetic nanoparticles can pull in small particles and hydrophobic contaminants.	More costly than natural materials like sand or coconut coir
Works quickly when a magnet is applied to guide the ferrofluid	Needs careful handling; can stain surfaces or stick to unintended areas
Can capture very fine particles that other filter layers might miss	Not as easy to source as charcoal or sand
Can often be collected and reused in multiple cycles	
Very effective to separate multiple types of debr (small vs large)	



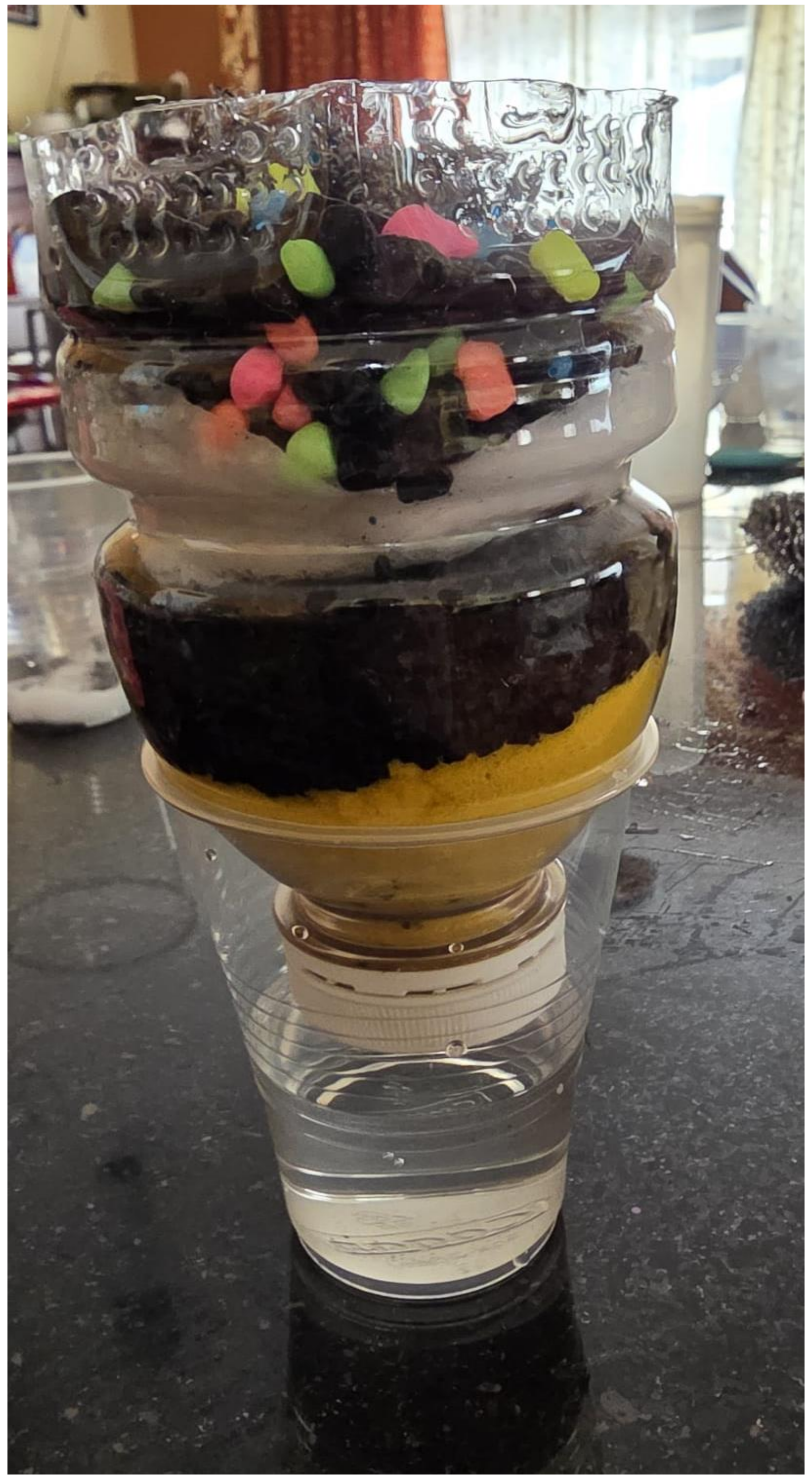


Data Analysis and Observation

Cleaning Method	Filter Material	Microplastics Removed (%) (av of 3 tests)	Water Clarity (Visual only 1-5) (av of 3 tests)	Filtration Time (s)	Observation
Physical and Filtration Methods	**Sand**	85%	3	60	Good fine filter; its effectiveness depends on grain size, packing, and particle size of the microplastics
Physical and Filtration Methods	**Pebbles**	75%	2	60	Pebbles provide strong drainage, but they do not directly remove microplastics and mainly trap large debris.
Physical and Filtration Methods	**Activated Charcoal**	90%	4	60	Activated charcoal effectively traps small particles and possibly can trap chemicals, but needs frequent replacement
Physical and Filtration Methods	**Coconut Coir**	40%	1	60	Coconut fiber is useful for trapping microplastics. The water was really contaminated, and this wasn't effective because of this
Physical and Filtration Methods	**Cotton**	85%	3	60	Cotton is a simple and effective layer for physically trapping microplastics, but it cannot remove chemicals and clogs relatively quickly
Magnetic Separation	**Steel Wool**	50%	4	60	Steel wool and magnets are excellent for quickly removing metallic debris, it cannot capture pure plastics or chemical contaminants and requires careful handling.
Nano-based Technique	**Ferro fluid**	95%	4	60	Ferrofluid shows promise in separating various levels of microplastics and oil efficiently, with fast, reusable, and visually impressive results

Multi-layer Filtration System

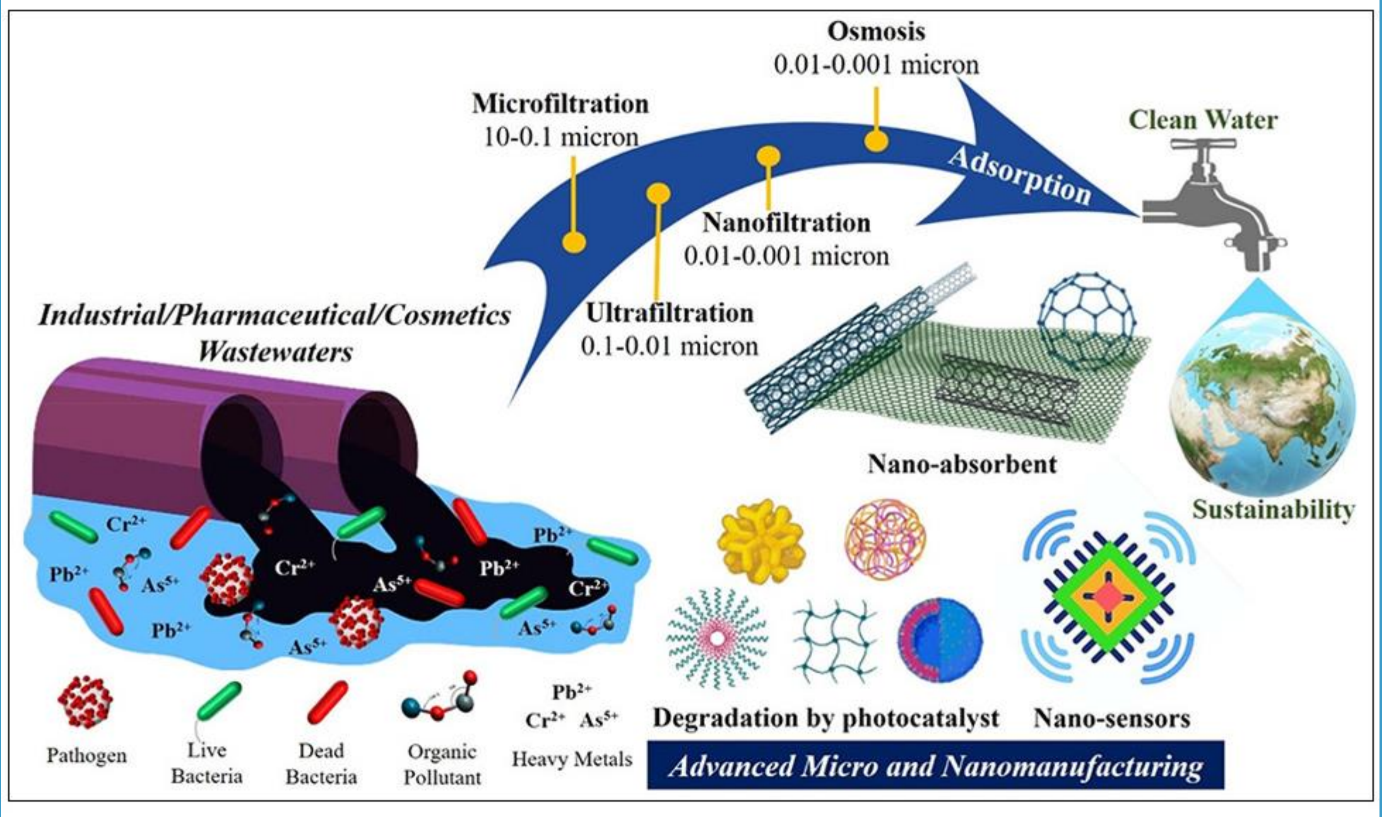
Area	Why it is used	What it filters
Pebbles	Provides structural support, improves drainage, prevents clogging of finer layers	Large debris, prevents filter from collapsing
Cotton	Fibrous layer that distributes water evenly and traps small particles	Small microplastics, some fine debris
Activated Charcoal	Adsorbs tiny particles and impurities	Small microplastics, chemical impurities
Sand	Fine physical filter that slows water slightly	Very small microplastics, sediments
Ferrofluid	Magnetic liquid that can be removed with a magnet	Tiny microplastics, remaining particles
Steel Wool & Magnet (optional)	Captures metallic particles in water	Metal debris



The filtration system layers pebbles, sand, cotton, activated charcoal, and ferrofluid to progressively remove debris and micro and nano plastics of all sizes, with an optional steel wool layer to capture metallic particles.

Project Conclusion

- Most micro and nano plastics come from bigger pieces of plastic breaking down in the environment.
- Plastic is made of polymers, which are long chains of molecules. These chains are nonpolar, so they do not mix with water, which is polar.
- Scientists say, “like dissolves like,” meaning nonpolar substances mix better with other nonpolar substances. That’s why micro and nano plastics will stick to oil but not to water.
- A solvent is a liquid that can dissolve another substance, so oil can act as a solvent to grab the micro and nano plastics.
- But then, how do we remove the oil from the water? This is where ferrofluids help.
- Ferrofluids are magnetic liquids. They are made by mixing tiny magnetic particles into a liquid, such as oil.
- Surfactants keep the particles from clumping together. When ferrofluid is added to water with microplastics, the plastics stick to it.
- .Then, a magnet can pull the ferrofluid out of the water, taking the microplastics with it!



Nanoparticles are one of the most efficient solution for cleaning up microplastic pollution from our waters

Challenges & Future Research in Nanotechnology

While nanotechnology offers innovative solutions for micro and nano plastic pollution cleanup, there are still challenges and areas for future research that need to be addressed before large-scale implementation.

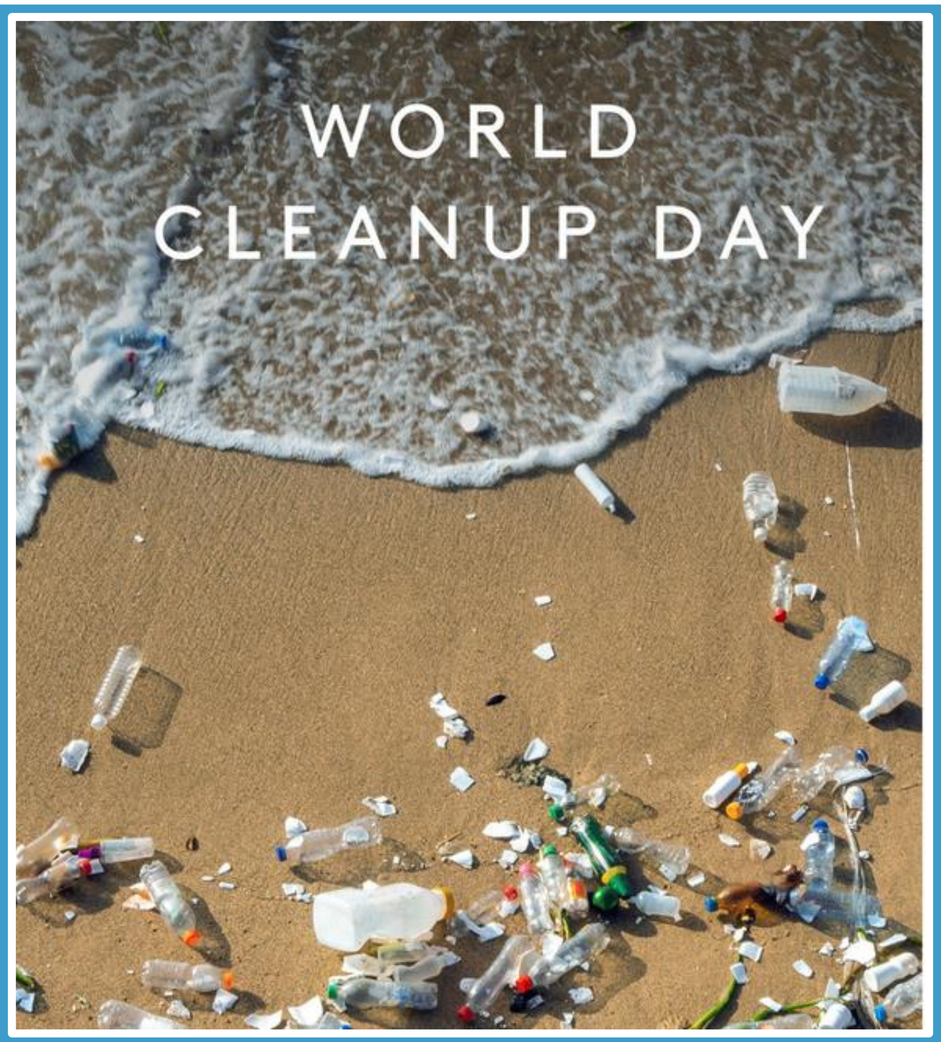
Area	Challenge	Future Growth
Cost	Many nanomaterials, such as ferrofluids and Nano sponges, are expensive to produce in large quantities	Finding cheaper, renewable nanomaterials (e.g., plant-based Nano sponges)
Scalability	Not economically feasible for large scale cleanups	Developing cost-effective mass production techniques. Partnering with industries to integrate nanotech into existing plastic cleanup plans.
Environmental Impacts	Some nanoparticles, especially those made of metals, could harm marine life if they enter the ecosystem and food chains.	Research on impacts and creating biodegradable or eco-friendly nanoparticles
Recovery	Nano pollution when some nanoparticles remain in the water after cleanup.	Developing self-recovering or self-degrading nanomaterials and improving retrieval methods
Regulation	There are no clear regulations on using nanoparticles for water pollution cleanup.	Establishing safe usage guidelines for nanotechnology in water pollution cleanup.

Source of Error

- Microplastics may not have been evenly mixed in the water, causing some trials to have more particles than others
- Errors could occur while measuring water volume, weighing materials, or in visual evaluations
- If filter layers were not the same thickness in every trial, results may vary.
- If the magnet was not held in the same place or for the same amount of time, ferrofluid removal could change.
- Not all ferrofluid may have been fully removed by the magnet, affecting the clarity of the results.
- Some materials like cotton or charcoal may clog during testing, slowing filtration and affecting performance.
- Microplastics might stick to the sides of the cup or beaker instead of being filtered.
- Environmental Factors - Temperature, lighting, or vibration could slightly affect measurements or visibility.

Project Application

- This project can help protect the environment by showing ways to remove micro and nano plastics from water before they reach rivers, lakes, and oceans.
- The filtration system I tested could be used in water treatment plants to improve how water is cleaned.
- It may also help industries reduce plastic pollution before wastewater is released into nature.
- The use of natural materials like sand, coconut coir, and cotton shows that low-cost and eco-friendly solutions can help reduce pollution.
- The use of ferrofluid and magnets demonstrates how advanced science and nanotechnology can remove even tiny plastic particles that are hard to see.
- In the future, this type of filtration system could help reduce the amount of micro and nano plastics that enter the food chain and eventually our bodies.
- By improving water cleanup methods, we can protect wildlife, ecosystems, and human health.



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  - For the opportunity and acceptance to present my project

Project Citations

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Saving Our Waters, One filter at a time…

Save Our Waters
OPTIMIZING
MICROPLASTIC
FILTRATION

Thank You

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