Clean Up Your Spill: Can We Fix The Mess?

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What is an Oil Spill ?

- OIL plays a vital role in our daily lives. It is one of the primary sources of energy in the world and used to power vehicles, to heat houses and other buildings, and to produce electricity. Derived from petroleum, a naturally occurring liquid formed millions of years ago beneath the Earth's surface, oil is essential for transportation, industry, and everyday products.
- Sometimes, the pipelines or carriers that transport petroleum or the rigs themselves can malfunction or break, leaking tons of oil into nature, including the ocean, rivers, lakes, and other sources of water. The pollution of the environment with crude or mineral oil or their by-products is called an **oil spill.**
- These are massively damaging to ecosystems, marine life, and coastal habitats, polluting water, destroying natural habitats, and disrupting the food chain.
- Oceanic oil spills emerged as a significant environmental issue in the 1960s due to the expansion of petroleum exploration and production and the introduction of supertankers, which could transport over 500,000 metric tons of oil, increasing the risk of large-scale spills.

An oil spill is the accidental release of liquid petroleum hydrocarbons products into a body of water, either by an oil tanker ship, offshore oil rig, pipelines and even recreational vehicles

What causes an Oil Spill ?

1. **Accidents:** It is the most common cause and occur due to collision, grounding, or sinking of oil ships or tankers
2. **Rig Leaks:** Oil rigs can have blowouts, equipment failures, corrosion or leaks.
3. **Pipeline Breaks** – Corrosion, damage, or poor maintenance can cause pipelines to rupture.
4. **Refinery Accidents** – Spills can occur during the extraction, refining, or transportation process.
5. **Improper Disposal** – Dumping oil waste into oceans or rivers, often illegally, contributes to spills.
6. **Natural disasters:** Earthquakes, storms, or tsunamis can cause infrastructure causing oil spills
7. **War and Sabotage** – Oil infrastructure can be targeted during conflicts, vandalism or terrorist acts

Why the effects of Oil Spill ?

- Environmental Effects
  - Water Contamination
  - Soil and Shoreline Damage
  - Air Pollution
- Wildlife Effects
  - Marine Life Suffocation
  - Birds and Marine Mammals
  - Food Chain Disruption
- Human and Economic Impact
  - Fisheries and Livelihoods Lost
  - Tourism Declines
  - Health Risks
  - Expensive Cleanup

Oil-spill cleanup

The enormous task of cleaning up oil spills in oceans and seas has burdened industry, government, and environmentalists for decades. The cleanup is almost always difficult, involving great amounts of time, resources, and money to remove the oil from the water, and still is often only partially successful. Cleaning up an oil spill is challenging and requires different methods depending on the type of oil, spill size, environment, and weather conditions.

Some oil sinks to the ocean floor, making cleanup even harder. Wildlife, like birds and marine mammals, must be cleaned and rehabilitated. Coastal communities suffer from economic losses in fishing and tourism.Today, however, scientists are coming to the rescue, developing a new technique that combines nanotechnology and magnetism.

Oil spill sorbents are materials specifically designed to absorb or adsorb oil from water or surfaces during an oil spill cleanup. They help in containing and removing oil to minimize environmental damage.

Oil-spill cleanup methods



1. Physical Methods
   - **Booms** – Floating barriers that prevent oil from spreading further in water.
   - **Skimmers** – Machines that remove oil from the water's surface.
   - **Absorbents** – Materials like sponges, sawdust, or synthetic pads soak up the oil.
   - **Vacuum Trucks** – Large vehicles that suck up oil from shorelines and water surfaces.

2. Chemical Methods
   - **Dispersants** – Chemicals sprayed on oil to break it into smaller droplets, allowing natural degradation.
   - **Solidifiers** – Turn oil into a solid, making it easier to remove.

3. Biological Methods (Bioremediation)
   - **Oil-Eating Microbes** – Special bacteria that break down oil into non-toxic substances.
   - **Nutrient Additives** – Help natural bacteria grow and speed up oil degradation.

4. Burning & Washing
   - **In-Situ Burning** – Oil is burned off the water's surface to reduce the spill quickly
   - **High-Pressure Washing** – Sprays hot water to remove oil from shorelines (but can harm wildlife).

5. Manual Cleanup
   - **Shovelling & Scraping** – Workers manually remove oil from beaches and rocky areas.

6. Nano-Absorbents
   - **Nanoparticles** like silica, carbon nanotubes, iron-based nanoparticles, nano-enhanced bacteria and graphene-based materials can absorb large amounts of oil due to their high surface area.

Why does this matter to me?

For the year 2024, six large spills (>700 tonnes) and four medium spills (7-700 tonnes) were recorded from tanker incidents.

The total volume of oil lost to the environment from tanker spills in 2024 was approximately 10,000 tonnes.

'Human error' cited as up to 8,000 litres of diesel spilled off B.C. coast - 2024

Between 60 and 100 litres of oil spilled in Vancouver English Bay - 2023

On April 20, 2010 an explosion of horizon oil rig released over 130 million gallons of crude oil into the Gulf of Mexico - Largest oil spill in history

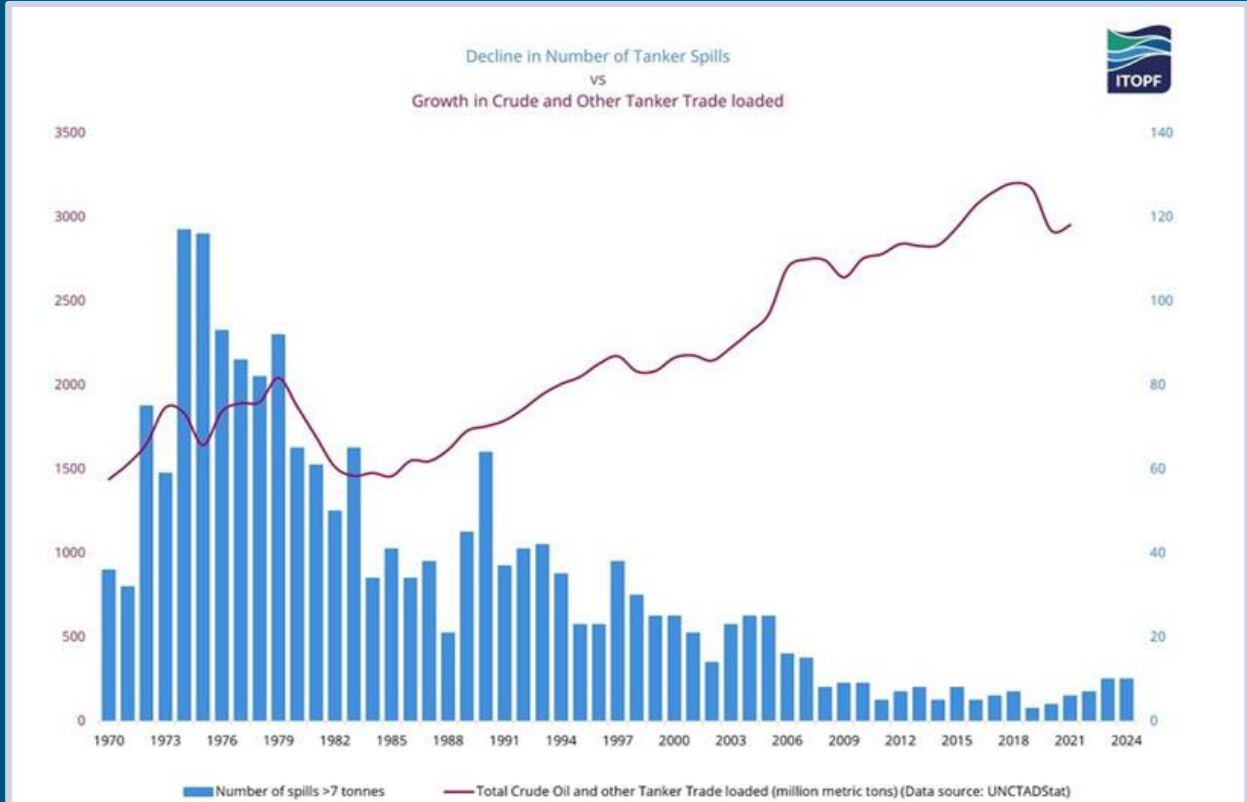


Figure 4: Decline in number of tanker spills vs growth in crude and other tanker trade loaded, 1970-2024
*UNCTADStat information is not available beyond 2021

My Project Objective

- Perform an experiment to see how oil reacts with water
- To test the effectiveness of different oil spill cleanup methods, such as booms, skimmers, dispersants, and nanoparticles.

My Project Hypothesis

- My project hypothesis is that among the various methods used to separate oil from water, nanoparticles will be the most effective. This will demonstrate that nanoparticles are one of the most efficient solution for cleaning up oil spills.

My Experiment - Materials

- Materials Used:

  - Tap Water
  - Cooking Oil
  - Sorbents
    - Cotton pads
    - Sponge
    - Coffee Filter papers
    - Dish Soap
    - Popsicle Sticks
    - Aluminium Foil
    - Mesh Sieve
    - Ferrofluid
  - Green Food Color
  - Timer
  - Liquid measuring cup
  - Petri Dishes
  - Spoon
  - Scissors
  - Gloves

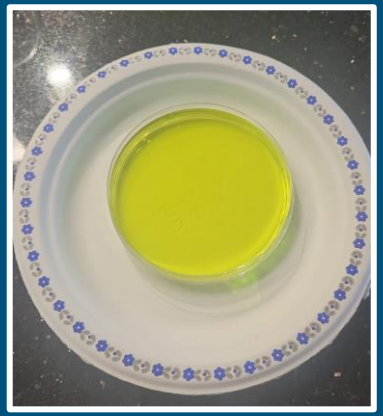
My Experiment - Procedure

Prepare Water

1. Measure ¼ cup of water into a petri dish
2. Dye the water with one drop of green color to create a contrast

Prepare Oil Mixture

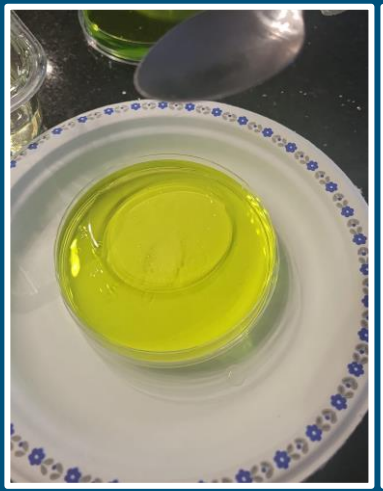
1. Add two teaspoons of oil into the petri dishes with the dyed water



Observation 1 - Interaction of oil with water

I observed that the oil forms a layer on top of the water and slowly spreads across the surface. This thin layer is called an oil slick. It sometimes forms small bubbles as well.
This happens because oil is hydrophobic that means it fail to mix with the water. Oil is also less dense.

Once it is thin enough, it will take on that sheen and rainbow look - signs of pollution
Even if you mix oil and water, it separates



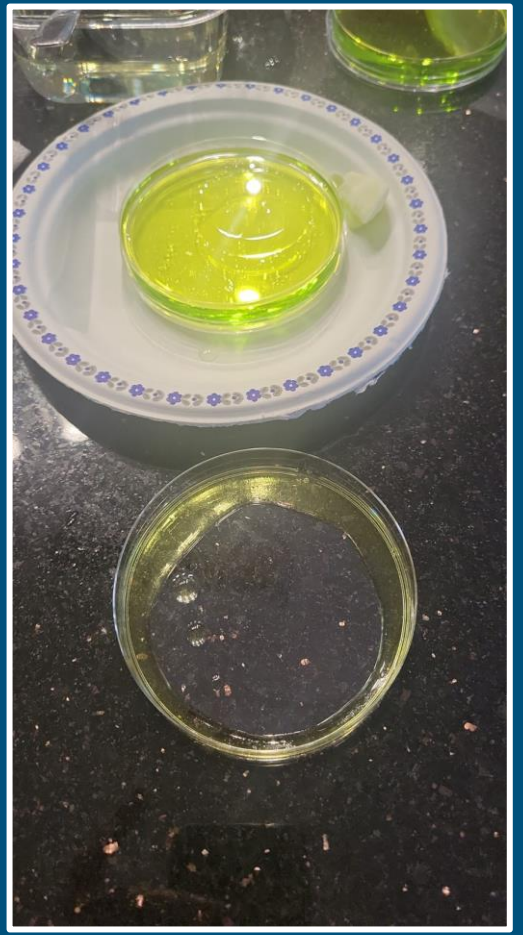
My Experiment - Procedure

Test Material 1 - Cotton Pad (Absorbent)

4. Start the timer for 30 secs
5. Absorb the oil from the water using a cotton pad
6. Squeeze out the oil into an empty dish
7. Measure the quantity of liquid

Observation 2

The cotton pad had good absorbency and absorbed the oil from the water but in the process also absorbed a lot of water.



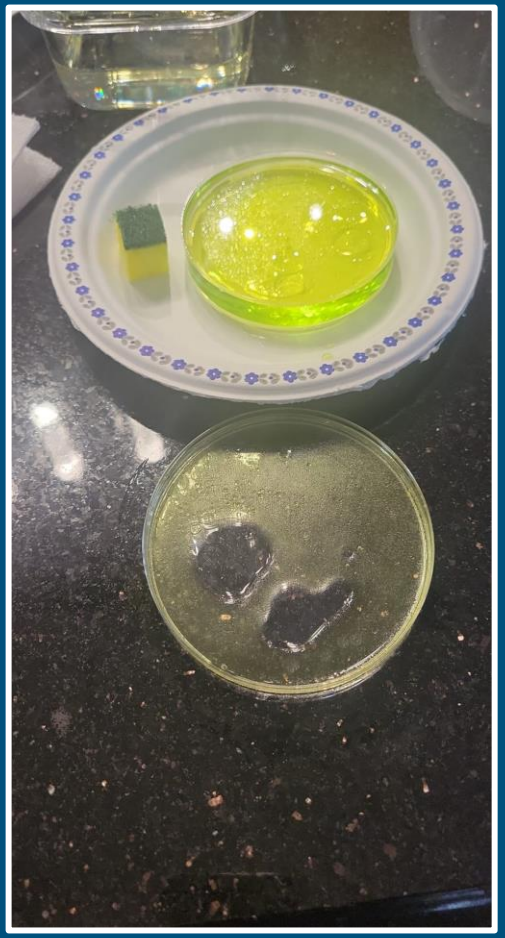
My Experiment - Procedure

Test Material 2 - Sponge (Absorbent)

8. Start the timer for 30 secs
9. Absorb the oil from the water using the sponge
10. Squeeze out the oil, from the sponge into an empty dish
11. Measure the quantity of liquid

Observation 3

It had the maximum absorption, but in the process also absorbed some water.



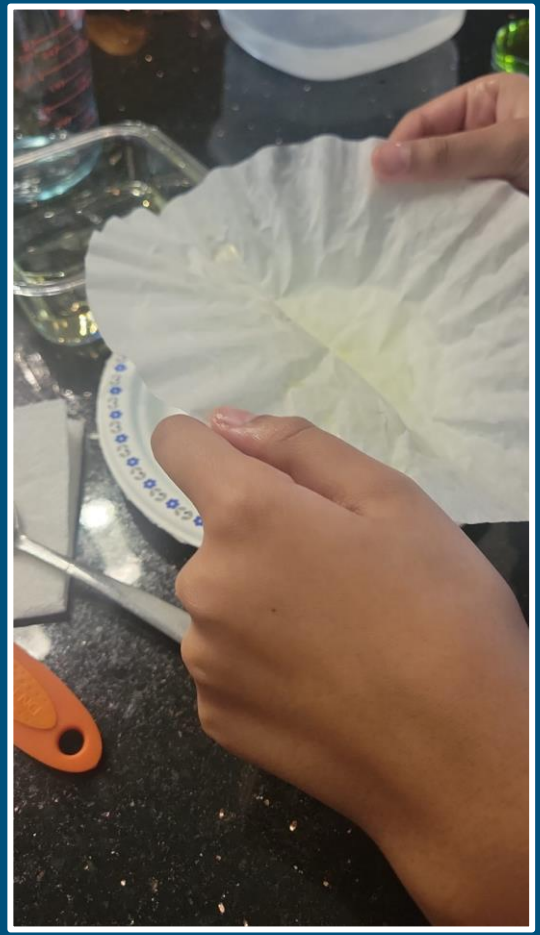
My Experiment - Procedure

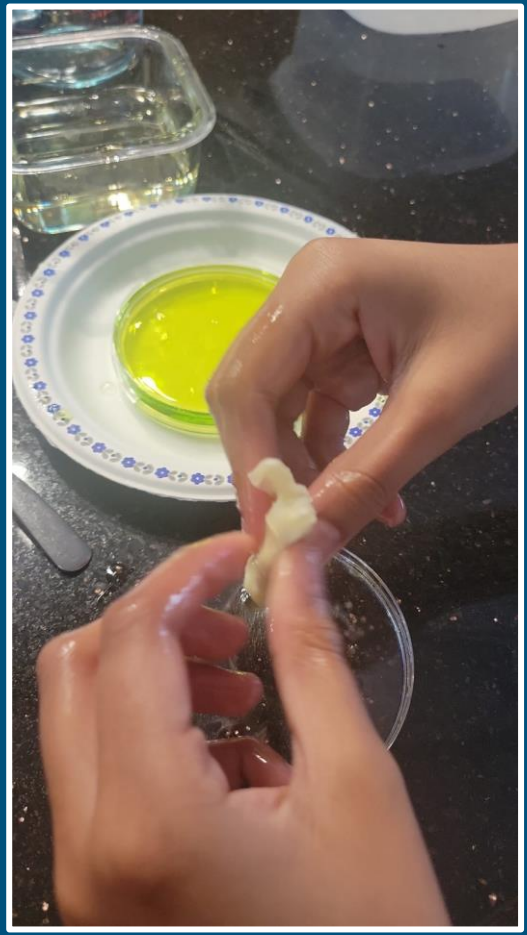
Test Material 3 - Coffee Filter Paper (Absorbent)

12. Start the timer for 30 secs
13. Slowly dip the coffee filter paper into the oil/water mix and filter the oil
14. Squeeze out the oil into an empty dish
15. Measure the quantity of liquid

Observation 4

The coffee filter paper filtered a lot of oil into the paper, but it was hard to squeeze out the oil from the paper

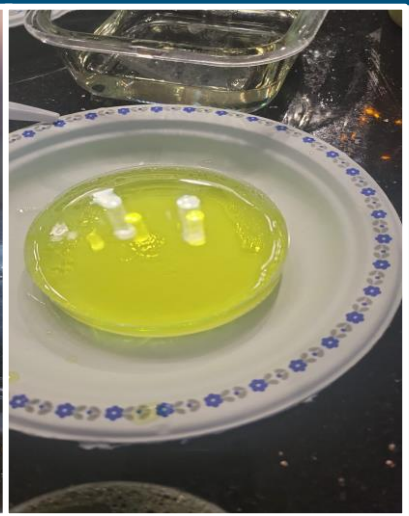




My Experiment - Procedure

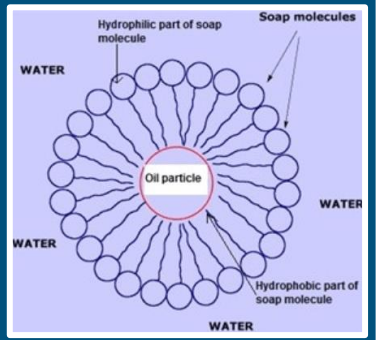
Test Material 4 - Dish Soap (Dispersant)

16. Spray dish soap into the oil water mix
17. Wait 30 secs
18. Take out the oil with the help of a spoon



Observation 5

The dish soap dispersed the oil and formed big droplets and moves to the edges of your bowl.
The dish soap is the dispersants, and the edges of the bowl are acting like a boom
This is because of its molecular structure
Hydrophobic End: Repels water and binds to oil.
Hydrophilic End: Binds to water and pulls oil away.



My Experiment - Procedure

Test Material 5 - Popsicle Stick / Aluminium Foil (Boom)

19. Separate the oil to a corner using a popsicle stick
20. Separate the oil to a corner using a aluminium foil

Observation 6

It helped to isolate the oil to a specific area or away from a specific area by creating a physical barriers. This made the clean up of oil easier

My Experiment - Procedure

Test Material 6 - Fine Mesh Sieve (Skimmer)

21. Using a sieve pour the oil and water through the sieve
22. Squeeze out the oil into an empty dish
23. Measure the quantity of liquid collected in filter

Observation 7

The oil water mix had to be sieved multiple time to completely filter out the oil. Having a cheesecloth on top of the filter increased the absorbency

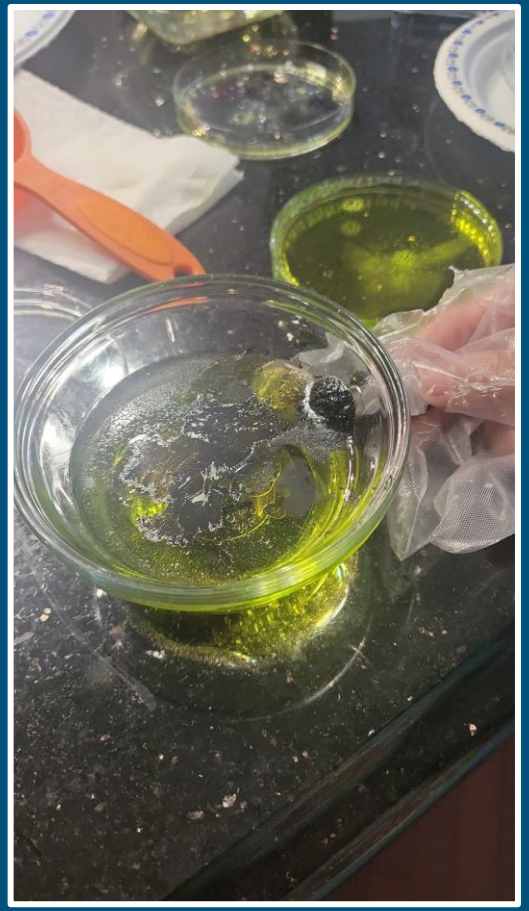
My Experiment - Procedure

Test Material 7 - Ferrofluid

24. Sprinkle the ferrofluid into the water-oil mixture
25. Mix it in
25. Use a magnet to pull out all the oil that got mixed in with the ferrofluid

Observation 8

This was very effective and did not absorb too much water.
Ferrofluid is made of tiny magnetic nanoparticles. When mixed with spilled oil, it binds to the oil molecules, making them respond to magnets.The oil can be separated from the ferrofluid afterward, meaning the oil could be collected for reuse instead of being wasted.



Data Analysis

- Oil to Water Ratio
  - Oil = 2 teaspoon
  - Water = ¼ cup = 12 teaspoon
  - Ratio = 2:12 = 1:6 (one part oil to 6 part water)

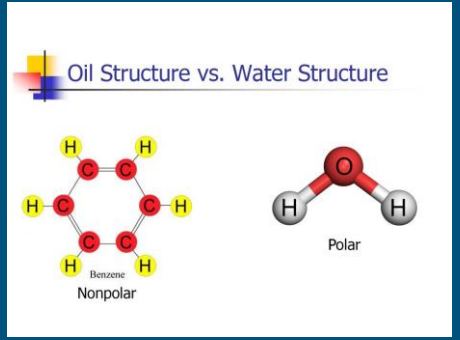
- Independent Variable (What we change):
  - Type of cleanup method (e.g., booms, skimmers, absorbents, dispersants, nanotechnology)

- Dependent Variables (What you measure):
  - Amount of oil removed (measured in milliliters or percentage cleaned).
  - Time taken for cleanup (in minutes).
  - Effectiveness of the method (visual observation or oil left in water).

Data Analysis and Observation

Cleaning Method	Sorbent Material	Before Cleanup		After Cleanup	Observation
		Water	Oil	Liquid	
Absorbent	**Cotton Pad**	12 teaspoon	2 teaspoon	11 teaspoon	Good absorbent but lot of water were also absorbed with the oil
Absorbent	**Sponge**	12 teaspoon	2 teaspoon	9 teaspoon	Better absorbent but some water was also absorbed
Absorbent	**Coffee filter**	12 teaspoon	2 teaspoon	10 teaspoon	It absorbed all the oil but it was hard to measure the collected oil
Dispersant	**Dish Soap**	12 teaspoon	2 teaspoon	14 teaspoon	Cleanup not effective by itself but separated the oil for easy cleanup.
Boom	**Popsicle stick**	12 teaspoon	2 teaspoon	14 teaspoon	Cleanup not effective by itself but separate the oil for easy cleanup
Boom	**Aluminum foil**	12 teaspoon	2 teaspoon	14 teaspoon	Cleanup not effective by itself but separate the oil for easy cleanup
Skimmer	**Fine Mesh Sieve**	12 teaspoon	2 teaspoon	10 teaspoon	Multiple efforts were required to absorb the oil and it is not time effective
Nano particle	**Ferrofluid**	12 teaspoon	2 teaspoon	10 teaspoon	**Faster cleanup and much more efficient**

Project Conclusion



- How does oil and water mix?

Water molecules are polar which means one end has a slight negative charge, the other a slight positive charge. Thus the water molecules can form hydrogen bonds and attach to other molecules that are also polar, like each other.

Oil molecules are nonpolar which means they can't form hydrogen bonds with water molecules.

This results in water and oil not being able to mix. Oil is lighter than water, so it floats on top of the water without mixing in.

- Nanotechnology as an efficient oil separation method

Magnetic nanoparticles (like iron oxide) are mixed with oil, making it magnetically responsive. Strong magnets can then pull the oil away from water without absorbing excess liquid.

Advantages include:

- Targets oil with high precision.
- Quick and efficient than traditional methods
- Oil can potentially be recovered and reused
- Prevents water absorption

Nanoparticles are one of the most efficient solution for cleaning up oil spills.

Challenges & Future Research in Nanotechnology for Oil Spill Cleanup

While nanotechnology offers **innovative solutions** for oil spill 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 spills	Developing cost-effective mass production techniques. Partnering with industries to integrate nanotech into existing oil spill response plans.
Environmental	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 oil spills.	Establishing safe usage guidelines for nanotechnology in oil spill response.

Thank You

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Project Citations

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