Role of Oceans in Climate Regulation

The capacity of ***oceans to absorb carbon comes at a cost***: acidification, pollution, and harm to marine ecosystems. It causes disruptions that cascade through ecosystems

The ocean's immense surface area makes it a tempting venue for carefully engineered solutions. So far, efforts to fight climate change have been land-biased, but studies tell us that the **land is saturated and can no longer support carbon capture**

Marine carbon sequestration is not a substitute for reducing emissions. It cannot offset fossil fuel combustion. However, as the world transitions toward net-zero, leveraging the oceans becomes indispensable

Oceans absorb **25% of human-made CO_2 emissions** and **90% of excess heat** caused by greenhouse gases, slowing down climate change effects.

This ability comes at a cost, causing:

- **Ocean acidification**, harming corals and shellfish.
- **Disrupted marine ecosystems**, affecting carbon sequestration and fisheries.
- **Warming and oxygen loss** in marine habitats.

Marine Carbon Dioxide Removal (mCDR)

To combat climate change, new approaches are focusing on oceans, offering two main strategies:

1. Biotic (Nature-Based) Approaches

- Use living systems like **mangroves, seaweed, and rivers**.
- Benefits: Support biodiversity and coastal protection.
- Challenges: Limited carbon capture capacity (under 1 billion tonnes/year) and shorter storage time (hundreds to a few thousand years).

2. Abiotic (Engineered) Approaches

- Use physical or chemical processes like **Ocean Alkalinity Enhancement (OAE)**:
    - Add alkaline materials to seawater, locking CO_2 for **thousands of years** as dissolved inorganic molecules.
- Potential to sequester **1 to 15 billion tonnes of CO_2/year**, much higher than biotic methods.
- Challenges: Expensive, energy-intensive, and public skepticism.

Promise and Challenges of mCDR

1. **Advantages:**
    - Can significantly enhance carbon storage in deep waters.
    - Supports global climate targets, especially for achieving **net-zero by 2050**.
2. **Challenges:**
    - Environmental risks (e.g., disrupting ecosystems, affecting marine biodiversity).
    - Difficulties in monitoring carbon storage in oceans.
    - Public skepticism about engineered methods compared to natural approaches.

Importance of mCDR for the Future

1. Oceans are **indispensable** for addressing climate change and achieving net-zero emissions.
2. The **Indian Ocean** has the potential to capture **25-40% of marine CO_2**, offering a critical edge against global warming.
3. Success depends on:
    - **Rigorous science**, ensuring methods are effective and safe.
    - **Robust governance**, establishing clear regulations.
    - **Public trust**, achieved through transparent communication and engagement.

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MCQ 1:
Consider the following statements regarding the role of oceans in moderating the Earth's climate:

1. Oceans absorb more than 25% of anthropogenic carbon dioxide emissions and excess heat generated by greenhouse gases.
2. Ocean acidification primarily impacts calcifying organisms such as corals and shellfish.
3. The carbon absorption processes of oceans are rapid and carry no ecological consequences.

Which of the statements given above is/are correct?
(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) All of the above

Answer:
(a) 1 and 2 only

Explanation:

- **Statement 1:** Correct. Oceans absorb 25% of anthropogenic CO_2 and over 90% of the excess heat.
- **Statement 2:** Correct. Acidification harms organisms like corals and shellfish that rely on calcium carbonate.
- **Statement 3:** Incorrect. Ocean carbon absorption processes are slow and have ecological consequences, including acidification and disrupted ecosystems.

MCQ 2:

Which of the following correctly distinguishes between biotic and abiotic marine carbon dioxide removal (mCDR) approaches?

1. Biotic methods primarily involve living systems like mangroves and macroalgae, while abiotic methods influence chemical properties like ocean alkalinity.
2. Abiotic methods are generally more scalable and offer longer-term carbon storage compared to biotic methods.
3. Both biotic and abiotic methods are capable of sequestering more than 10 billion tonnes of carbon dioxide annually.

Select the correct answer using the codes below:
(a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) All of the above

Answer:
(a) 1 and 2 only

Explanation:

- **Statement 1:** Correct. Biotic methods use ecosystems, while abiotic methods involve engineered solutions like Ocean Alkalinity Enhancement.
- **Statement 2:** Correct. Abiotic methods offer higher scalability and permanence (up to tens of thousands of years).

Statement 3: Incorrect. Only abiotic methods can sequester over 10 billion tonnes of CO_2 annually, while biotic methods are capped at less than 1 billion tonnes/year.