DUST-DRIVEN OCEAN FERTILIZATION - GEOGRAPHY

NEWS: Dust carried by wind from drought-stricken southern Africa caused a bloom of marine phytoplankton off the southeast Madagascar coast from November 2019 through February 2020.

WHAT'S IN THE NEWS?

About Ocean Fertilization

Ocean fertilization or ocean nourishment is a type of technology for carbon dioxide removal from the ocean based on the purposeful introduction of **plant nutrients to the upper ocean** to increase marine food production and to **remove carbon dioxide from the atmosphere**.

Ocean nutrient fertilization, **for example iron fertilization**, could stimulate photosynthesis in phytoplankton. The phytoplankton would convert the ocean's dissolved **carbon dioxide into carbohydrate,** some of which would sink into the **deeper ocean before oxidizing**.

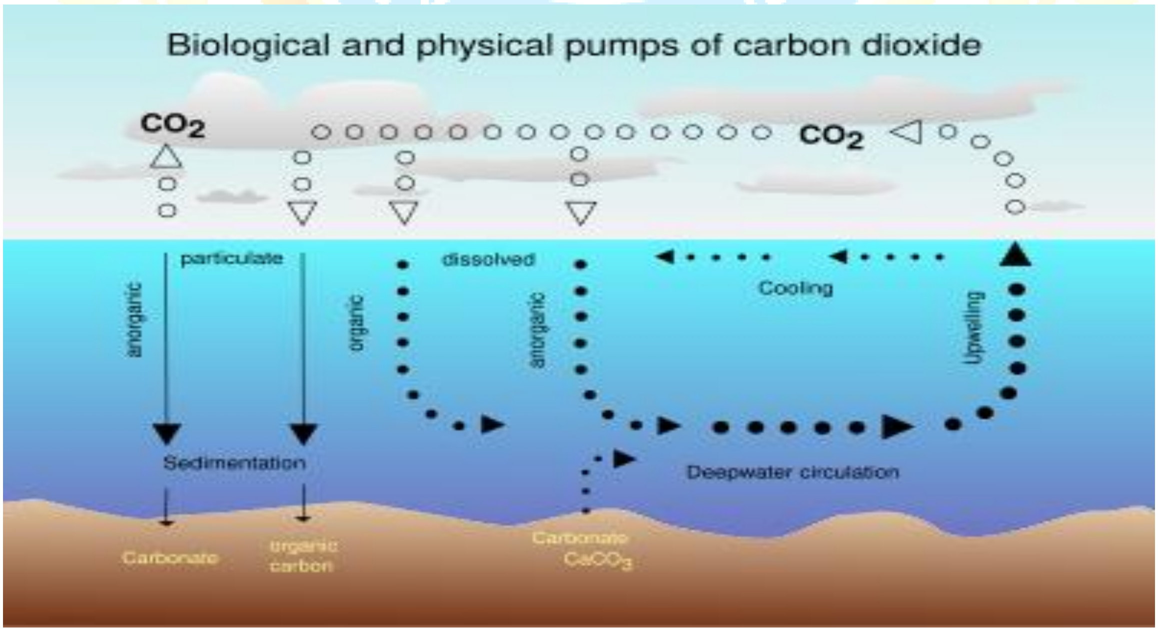
More than a **dozen open-sea experiments** confirmed that adding iron to the ocean increases photosynthesis in phytoplankton by up to 30 times.

About Iron Fertilization

Iron fertilization is the intentional introduction of **iron-containing compounds (like iron sulfate)** to **iron-poor areas** of the ocean surface to **stimulate phytoplankton production**.

This is intended to enhance biological productivity and/or **accelerate carbon dioxide (CO2) sequestration** from the atmosphere. Iron is a trace element necessary for photosynthesis in plants.

It is **highly insoluble in sea water and in a variety of locations** is the limiting nutrient for phytoplankton growth. Large algal blooms can be created by supplying iron to iron-deficient ocean waters. These blooms can nourish other organisms.



Sources of Dust

The primary sources of dust are large desert regions, **such as the Sahara in Africa, the Gobi in Asia, and** the **deserts of Australia**. Winds lift dust particles into the atmosphere, where they can travel thousands of kilometers across continents and oceans.

The most well-studied dust transport is from the **Sahara Desert to the Atlantic Ocean**, including regions as far away as the Caribbean and the Amazon basin.

Nutrient Content of Dust

Dust contains various essential nutrients, **including iron, phosphorus, and silicon.** Iron is particularly crucial for ocean fertilization because it is a limiting nutrient in many parts of the ocean.

In regions like the **Southern Ocean and the North Pacific**, where nitrogen and phosphorus are abundant but iron is scarce, the deposition of **iron-rich dust** can **boost phytoplankton productivity.**

Mechanism of Ocean Fertilization

When dust settles on the ocean surface, iron and other nutrients dissolve in seawater and become available to phytoplankton.

This fertilization stimulates the growth of these microorganisms, leading to an increase in primary production.

Phytoplankton, through photosynthesis, absorb carbon dioxide from the atmosphere, thus playing a critical role in the global carbon cycle. The enhanced growth of phytoplankton can lead to **increased sequestration of carbon as they die and sink to the ocean floor**, trapping carbon in the deep ocean for long periods.

Impact on Marine Ecosystems

- **Enhanced Phytoplankton Growth:** Dust-driven ocean fertilization can lead to phytoplankton blooms, particularly in high-nutrient, **low-chlorophyll (HNLC) regions** where iron is the limiting factor. This enhances the marine food web, supporting higher trophic levels, including zooplankton, fish, and marine mammals.
- **Carbon Sequestration:** The increase in phytoplankton growth facilitates greater carbon capture from the atmosphere. This process, known as the **"biological pump,"** has implications for mitigating the effects of climate change.
  However, the efficiency of this process in **long-term carbon sequestration** is still a subject of scientific research.
- **Nitrogen Fixation:** Certain types of phytoplankton, such as **cyanobacteria**, are nitrogen fixers, meaning they can **convert atmospheric nitrogen into a form usable by other marine organisms**.
- **Algal Blooms:** While dust deposition can have positive effects on marine productivity, excessive fertilization can lead to harmful algal blooms (HABs).
  These blooms can **deplete oxygen levels in the water, causing dead zones** where marine life cannot survive.

Regional Impact

- **North Atlantic:** The **Sahara Desert is the largest source of dust to the North Atlantic Ocean**. This dust provides significant iron input to the Atlantic, influencing phytoplankton productivity and carbon cycling.
- **Southern Ocean:** Dust from Patagonia and **Australia fertilizes the Southern Ocean**, a key region for global carbon sequestration. Here, iron is often the limiting nutrient for phytoplankton growth, making dust input particularly important.
- **Pacific Ocean:** The **Gobi Desert is a major source of dust to the North Pacific Ocean**. Dust-driven fertilization in this region can affect marine productivity, particularly in areas where iron is the limiting nutrient.

Climate Change and Dust Transport:

Climate change is likely to affect both dust production and transport patterns. Changes in temperature, precipitation, and wind patterns may alter the amount of dust available for ocean fertilization. Additionally, **human activities, such as land-use changes, deforestation, and desertification, can influence the amount of dust generated from arid regions**.

On the other hand, increased ocean fertilization through dust deposition has the potential to mitigate some effects of **climate change by enhancing carbon sequestration in the oceans**. However, the relationship between dust-driven ocean fertilization and climate change is complex, and there are uncertainties regarding the **long-term impact on global carbon cycling**.

Artificial Ocean Fertilization:

There has been growing interest in artificially replicating the process of ocean fertilization as a geoengineering solution to combat climate change. Proponents argue that adding iron to the ocean could enhance **phytoplankton growth and carbon sequestration, potentially reducing atmospheric CO_2 levels.**

However, this approach is controversial due to the potential unintended consequences, including disruption of marine ecosystems, **creation of dead zones, and the uncertain long-term efficacy of carbon sequestration.**

International regulations, such as the London Protocol, currently restrict large-scale iron fertilization experiments in the ocean due to the potential environmental risks.

Source: https://www.downtoearth.org.in/wildlife-biodiversity/unusual-plankton-bloom-off-madagascar-coast-driven-by-drought-in-southern-africa-shows-study