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Carbon sequestration: A review

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What is carbon?

Carbon is life in many ways. A Chemical element like nitrogen or Hydrogen, carbon is basic building block of biomolecules. It exists on earth in solid, gaseous forms. For examples- carbon is in graphite and diamond, but can also combine with oxygen molecules to form gaseous carbon dioxide (CO_2).

Man-made sources of carbon in gaseous form come from the burning of fossil fuels such as natural gas, coal and oil for use in power generation and transportation. The build-up of CO_2 and other greenhouse gases in the atmosphere can trap heat and contribute to climate change.

Carbon sequestration

Carbon dioxide is the most commonly produced greenhouse gas. One of the approaches to reducing CO_2 Concentration in the atmosphere is carbon sequestration. Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. It is one method of reducing the amount of carbon dioxide in the atmosphere with the goal of reducing global climate change. **Sequestration** means something that is locked away for safe keeping, the trapping of a chemical in the atmosphere or environment and its isolation in a natural or artificial storage area.

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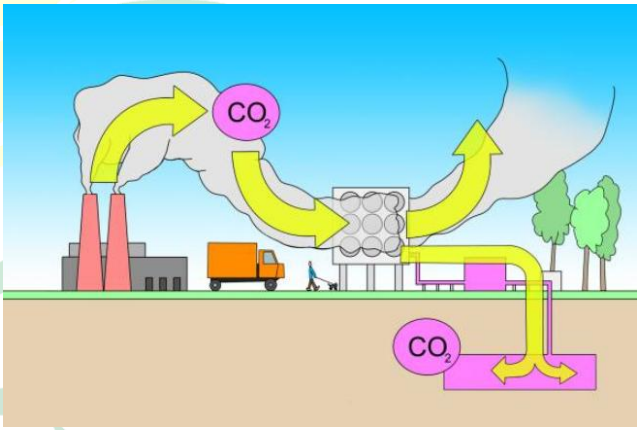
How Does Carbon Sequestration Work?

How carbon sequestration works depends on the type of carbon sequestration used. However, one of the technologies discussed by policymakers, engineers and scientists is carbon capture and storage (CSS). It is a geoengineering process where carbon dioxide is first separated from other gases contained in industrial emissions. It is then compressed and transported to a location where it is safely isolated from the atmosphere for long-term storage. CSS typically refers to the capture of carbon dioxide at its direct source of emission before releasing into the atmosphere, but may also refer to techniques used to remove carbon dioxide from the air, like the use of scrubbing towers and 'artificial trees'. Once the carbon dioxide is captured and transported, it can also be stored in other suitable locations such as geological formations like deep saline formations. These are sedimentary rocks whose pore spaces are saturated with water containing high concentrations of dissolved salts.



The carbon dioxide may also be stored in depleted oil and gas reservoirs or the deep ocean. These locations are in such a way that the carbon dioxide, once released there, would be used constructively than it would have, had it been released in the atmosphere. For instance, carbon sequestration in the ocean means the plankton at the ocean surface will convert the carbon dioxide, through photosynthesis, into oxygen, much like the trees and land plants do on land.

Carbon sources and carbon sinks

Anthropogenic activities such as the burning of fossil fuels have released carbon from its long-term geologic storage as coal, petroleum, and natural gas and have delivered it to the atmosphere as carbon dioxide gas. Carbon dioxide is also released naturally, through the decomposition of plants and animals. The amount of carbon dioxide in the atmosphere has

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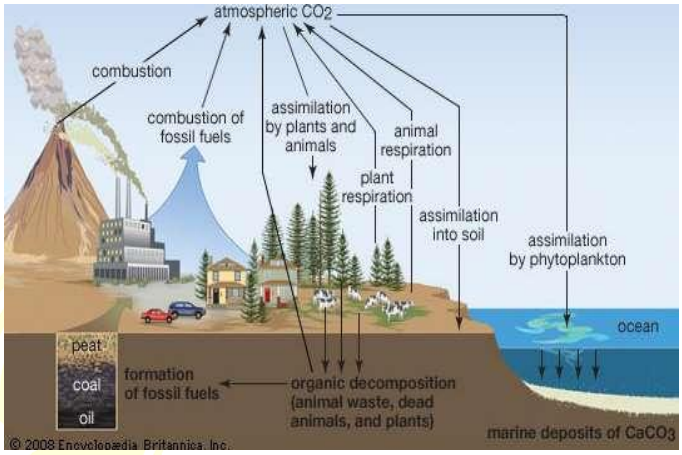
increased since the beginning of the industrial age, and this increase has been caused mainly by the burning of fossil fuels. Carbon dioxide is a very effective greenhouse gas—that is, a gas that absorbs infrared radiation emitted from Earth's surface. As carbon dioxide concentrations rise in the atmosphere, more infrared radiation is retained, and the average temperature of Earth's lower atmosphere rises. This process is referred to as global warming.

Reservoirs that retain carbon and keep it from entering Earth's atmosphere are known as carbon sinks. For example, deforestation is a source of carbon emission into the atmosphere.CARBON CYCLE Carbon is transferred naturally from the atmosphere to terrestrial carbon sinks through photosynthesis; it may be stored in above ground biomass as well as in soils.



Types of Carbon Sequestration

1. **Biological Carbon Sequestration**
    - **In oceans:** Naturally, oceans absorb about 25% of the carbon dioxide emitted through human activities each year. When the ocean absorbs carbon dioxide, it results in a negative flux, and conversely, when the ocean releases carbon dioxide into the atmosphere, it results in a positive atmospheric flux. Colder and nutrient-rich parts of the ocean absorb more carbon dioxide than the warmer parts of the ocean. As such, the polar regions absorb more carbon dioxide and by 2100, most of the global oceans are expected to be made up of carbon dioxide, potentially altering the chemistry of the ocean, making it more acidic.
    - **In forests:** plant-rich landscapes like forests, rangelands and grasslands absorb about 25% of the global carbon emissions. When the trees, branches and leaves die and fall to the ground, they release the carbon they had stored into

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the soil. Deforestation and wildfires continue to diminish forests as a carbon sink.

- **In soils:** carbon can be sequestered in soil by plants through photosynthesis. As such, agroecosystems degrade and deplete the soil organic carbon levels. Luckily, soil can also store carbon as carbonates, created over thousands of years when carbon dioxide dissolves in water and percolates the soil. The carbonates are inorganic and can store carbon for tens of thousands of years while soil organic matter stores carbon for a few decades.
- **In grasslands:** grasslands and rangelands are more reliable areas of storing carbon than forests due to the rapid wildfires and deforestation affecting forests. Grasslands can sequester more carbon underground and when they burn, the carbon stays fixed in the roots and soil instead of in leaves and woody biomass. Granted, forests can store more carbon than grasslands, but in unstable conditions like due to climate change, grasslands can become more resilient.

2. Geological Carbon Sequestration

This is where carbon dioxide is stored in underground geologic formations, such as in rocks. Industrial sources of carbon dioxide such as steel or cement production companies or energy-related sources like power plants or natural gas processing facilities will release their carbon dioxide, which is then injected into porous rocks for long-term storage. Such carbon capture and storage allows the use of fossil fuels until a substitute energy source is introduced on a large scale.

3. Technological Carbon Sequestration

This is a relatively new way of capturing and storing carbon dioxide and continues to be explored by scientists. The method uses innovative technologies, which means scientists are also looking into more ways of using carbon dioxide as a resource rather than removing it from the atmosphere and directing it elsewhere.

- **Graphene production:** technology is being used to produce graphene from carbon dioxide as its raw material. Graphene is a technological material, used to create screens for smartphones and other technological devices. Its production is limited to specific industries but if carbon can be used to make more of the product, it might be

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a viable resource and an effective solution in reducing carbon's emissions from the atmosphere.

- **Engineered molecules:** scientists are engineering molecules that can take new shapes by creating new compounds capable of singling out and capturing carbon dioxide from the air. These engineered molecules act as filters and only attract the element they are engineered to seek.
- **Direct air capture (DAC):** this is a means of capturing carbon dioxide from the air using advanced technology plants. The plants would seek to capture carbon dioxide from the air as the artificial ones do. It is an effective technological method of sequestrating carbon but it has its challenges. The project is energy-intensive and is also expensive to implement on a mass scale. It is estimated that between $500 and $800 is required for every ton of carbon removed.

4. Industrial Carbon Sequestration

This is not a widely renowned method, but it can be used in some industries. They capture the carbon in three ways from a power plant, pre-combustion, post-combustion and oxyfuel.

- **Pre-combustion:** the carbon is captured in power plants before the fuel is burned. The aim is to remove the carbon from coal before it is burned. The coal is reacted with oxygen to produce synthesis gas, a mixture of carbon monoxide and hydrogen gases. The hydrogen is removed and either burned directly as fuel or compressed and stored in fuel-cell cars. Water is then added to the carbon monoxide to make carbon dioxide which is then stored and the extra hydrogen is stored with the hydrogen previously removed.
- **Post-combustion:** here, carbon is removed from a power station's output after the fuel has been burned. This means waste gas is captured and scrubbed clean of their carbon dioxide before they travel up smokestacks. This is achieved by passing the gases through ammonia, which is then blasted clean with steam, releasing carbon dioxide for storage.
- **Oxyfuel or oxy-combustion:** the point is to burn fuel in more oxygen and store all the gases produced as a result. Instead of laboriously separating the carbon dioxide from other waste gases, the process traps the entire output from the smokestacks and stores it all. Pure oxygen is blown into the furnaces to purify the exhaust, so the fuel

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burns completely, producing relatively pure steam and carbon dioxide gas. Once the steam is removed by cooling and condensation, making it into water, the carbon dioxide can be safely stored.

Dangers of artificial carbon sequestration

We know that trees remove carbon dioxide from the atmosphere and can do it very well. They also provide us, animals and insects food and shelter. It's all the more reason for us to preserve the forests we have left and to restore ones we've destroyed. We'd be simply replacing what we have taken in an effort to restore balance. It's pretty simple really - consume less + more trees + renewable energy sources = less carbon dioxide = less warming. Artificial carbon sequestration on the other hand is costly, energy intensive, relatively untested and has no other side benefits.

Carbon sequestration and environmental benefits from no-till systems

Agricultural carbon (C) sequestration may be one of the most cost-effective ways to slow processes of global warming. Information is needed on the mechanism and magnitude of gas generation and emission from agricultural soils with specific emphasis on tillage mechanisms.

This work reviews the scientific foundation and basic research on tillage-induced carbon losses and environmental benefits of soil carbon. With no tillage, crop residues are left more naturally on the surface to protect the soil and control the conversion of plant C to soil organic matter (SOM) and humus through C cycling. Numerous environmental benefits may result from agricultural activities that sequester soil C and contribute to environmental security. As part of no-regret strategies, practices that sequester soil C help reduce soil erosion and improve water quality and are consistent with more sustainable and less chemically dependent agriculture.

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