INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)
ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue VII, July 2024

Bio-Char Used for Carbon Sequestration and to Balance the CO_2 Concentration in Atmosphere: A Review

Rakhman Sarwono

Research Centre for chemistry – National Research and Innovation Agency, Komplek PUSPIPTEK Serpong, Tang-sel, Banten (15314), Indonesia.

DOI : https://doi.org/10.51583/IJLTEMAS.2024.130706

Received: 10 July 2024; Accepted: 20 July 2024; Published: 29 July 2024

Abstract: The Carbon concentration in earth is closed system, therefore, the contain of carbon in each elements are different. The concentration of CO_2 in atmosphere is lower compared with N_2 and O_2 gas but CO_2 concentration is great effect to the atmosphere temperature, it may cause the global warming and climate change. The CO_2 concentration in atmosphere should be maintained to slower increase in order to reduce the effect of CO_2 in atmosphere. Balancing of carbon positive and negative is concerned to maintain the CO_2 concentration in atmosphere. Bio-chars are materials carbon that can be used as soil amendment to increase crop production. Recently, the carbon positive more than the carbon negative, resulted the CO_2 concentration in atmosphere was increased gradually. Biochar has been possibility to produce in a large quantity to utilize of waste biomass. We needs a large quantity of biochar to be produced and mixed with soil and store in the ground as carbon sequestration, those biochar increase the soil fertility. Scenarios stabilization wedge represents an activity that starts at zero reduction of emissions in 2005 and increase linearly until it accounts for 1 GtC/ year or 1 wedges reduced carbon emissions in the year 2055.

Key words: CO_2, positive, negative, balance. Biochar, stabilization

I. Introduction

Greenhouse gas such as CO_2, CO, CH_4, water and NOx are entered to the atmosphere might cause the global warming. Carbon dioxide concentrations are rising mostly because of the fossil fuels that people are burning for energy. Fossil fuels like coal and oil contain carbon that plants pulled out of the atmosphere through photosynthesis over many millions of years; we are returning that carbon to the atmosphere in just a few hundred. Since the middle of the 20th century, annual emissions from burning fossil fuels have increased every decade, from an average of 3 billion tons of carbon (11 billion tons of carbon dioxide) a year in the 1960s to 9.5 billion tons of carbon (35 tons of carbon dioxide) per year in the 2010s. The concentration of CO_2 in air has increased from 270 ppm before industrial revolution to close to 405 ppm today.[1] Based on analysis from NOAA's Global Monitoring Lab, global average atmospheric carbon dioxide was 414.72 parts per million (ppm) in 2021[2] In May 2022 the concentration CO_2 in atmosphere is 421 ppm.[3] The Intergovernmental Panel on Climate Change (IPCC) has forecast an increase in global temperature 1.8 ^oC by 2100, largely as a result of anthropogenic CO_2 emissions.[4] About half of these CO_2 emissions are from distributed sources such as transportation and power plants.[5]

Human have led to a massive increase in CO_2 emissions as a primary greenhouse gases that are contribution to climate change. The emission of CO_2, which is thought to contribute to global warming, is a byproduct of the combustion of fossil fuels. It will increases in extreme weather and global temperatures, research is developing into CO_2 capture to help reverse climate change. CO_2 is one of the main culprit molecules of global warming because of its ability to trap energy from infrared (IR) radiation in the atmosphere. Radiation reflecting off of the earth's surface within the IR spectra is easily absorbed by CO_2, causing vibrations within the molecule and trapping the energy.[6]

A new material capable of substantially reducing carbon dioxide (CO_2) emissions at room temperature and normal atmosphere pressure. There are two main ways to stop the amount of greenhouse gases from increasing: we can stop adding them to the air, and we can increase the Earth,s ability to pull them of the air. There are many terms in CO_2 concentration in atmosphere, carbon positive, negative and neutral. Carbon positive is if the amount of CO_2 emissions remove from the atmosphere is less than the amount of CO_2 emissions put into the atmosphere. Carbon negative is if the amount of CO_2 emissions remove from the atmosphere is bigger than the amount of CO_2 emissions put into the atmosphere. Carbon neutral if the amount of CO_2 emissions put into atmosphere is the same as the amount of CO_2 emissions remove from the atmosphere.[7]

Increasing CO_2 concentration into atmosphere (carbon positive) by naturally mainly come from of breath of human life, such as animals, human being and plantation at night. Increasing CO_2 into atmosphere by human activity come from burning fuel, such as fossil fuels, coal, and biomass. Cement processing also release CO_2 gas. The decrease of CO_2 out from atmosphere (Carbon negative) coming from the activities photosynthesis of the plantations. The decrease of CO_2 out from atmosphere by naturally coming from absorbing by ocean, lands and catching by the air at atmosphere. The schematic of carbon positive and negative as shown in Figure 1.

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II. Carbon Source and Cycle

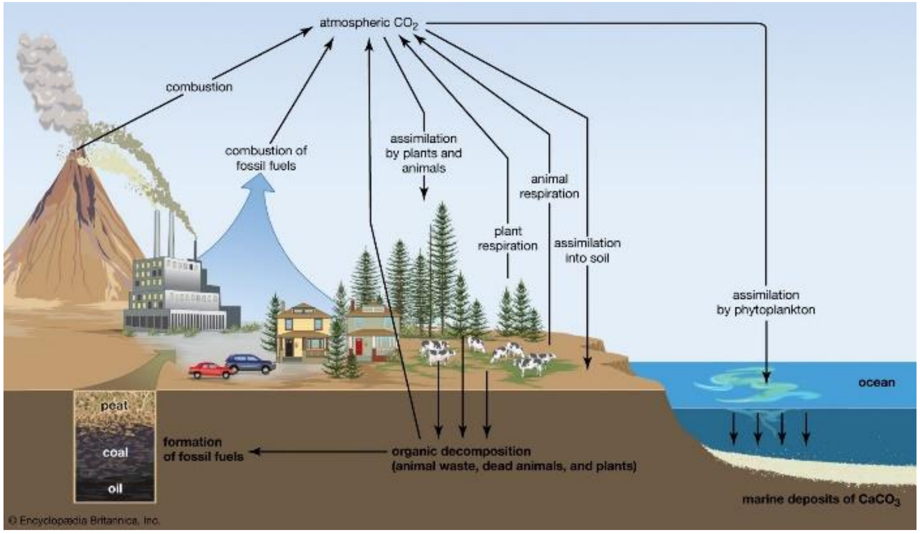

Figure 1. Carbon cycle.[8]

There are many sources and carbon sinks naturally and anthropogenic (Fig.1) to enhance the carbon positive or negative.

Carbon positive occurs in many ways.

1. Fossil oil were mined and used as a fuel, the CO_2 gas release to atmosphere.
2. Degradation of $CaCO_3$ → $CaO + CO_2$, CO_2 entering the atmosphere.
3. Gas from volcano, the CO_2 entering to the atmosphere.
4. Dead bodies degraded and the gas entering to atmosphere, including the creature respiratory will CO_2 entering the atmosphere.
5. Respiration plants, animals and humankind are releasing of CO_2 into atmosphere.
6. Burning fuels, coals and biomass are also release of CO_2 into atmosphere.
7. Degradation of iceberg in glacier
8. Volcano gas entering into atmosphere

Carbon negative occurs in many ways.

1. Process of photo-synthesis of plant they absorbed of CO_2 from atmosphere and metabolisms to plant body.
2. Plants were eaten by animals for metabolisms into animals tissue.
3. Dead plants and animals were buried in the layer of soil that carbon will degrade become fossil that can stand in a long time.
4. Ocean was absorbed the CO_2 from atmosphere. The ocean temperature will influence of the capacity of absorb and desorb of CO_2 in the water of ocean.
5. Land absorber CO_2 from atmosphere

III. Several Methods of Remove Co_2

Carbon negative was thought of the effort of reducing the CO_2 atmospheric concentration in order to maintain the level of CO_2 concentration. It's can be done by naturally and anthropogenic processes. Carbon removal includes a range of approaches that remove carbon dioxide (CO_2) directly from the atmosphere. Some familiar approaches are tree planting and increasing carbon storage in soil — nature-based solutions which leverage and enhance natural carbon sinks. These are already being used around the world; however, many are ready for broader application and would benefit from public and private funding to scale up faster and improve inventory and monitoring capacity. There are six options for removing carbon from the atmosphere:[9]

1). Forests, Photosynthesis removes carbon dioxide naturally.

The leaves of the forest trees are doing photosynthesis process. Photosynthesis is the process by which plants use sunlight, water, and carbon dioxide to create oxygen and energy in the form of sugar. Trees are especially good at storing carbon removed from the atmosphere by photosynthesis. The forest appear to be one of the more efficient forms of vegetation for converting light energy to plant material.[10] Expanding, restoring and managing forests to encourage more carbon uptake can leverage the power of photosynthesis, converting carbon dioxide in the air into carbon stored in wood and soils. Plants photosynthesis can slowdown climate change but can't stop it.[11]

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2). Farms Soils naturally store carbon

Agricultural soils are running a big deficit due to intensive use. Even small increases in soil carbon per acre could be impactful. Building soil carbon is good for farmers and ranchers, too, as it can increase soil health and crop yields. Integrating trees on farms can also remove carbon while providing other benefits, like shade and forage for livestock. Agriculture together with animal husbandry can be one of solutions to the problems of greenhouse gas emissions and climate change.[12] Farming has been shown to absorb nearly 3% of global carbon emissions,[13] some scientists estimate that with enough regenerative farming, the global carbon emissions absorbed back into the soil could be up to 15%.[14]

3). Bio-energy with Carbon Capture and Storage (BECCS)

Bio-energy with Carbon Capture and Storage (BECCS) is another way to use photosynthesis to combat climate change. However, it is far more complicated than planting trees or managing soils and it doesn't always work for the climate. BECCS is the process of using biomass for energy in the industrial, power or transportation sectors. Capturing its emissions before they are released back to the atmosphere; and then storing that captured carbon either underground or in long-lived products like concrete. If BECCS causes more biomass to grow than would otherwise or stores more carbon instead of releasing it back into the atmosphere, it can provide net carbon removal. Microalgal-based CO_2 sequestration aiming to sequester carbon back to the biosphere, ultimately reducing greenhouse effects.[15]

4). Direct Air Capture (DAC)

Direct air capture (DAC) is the process of chemically scrubbing carbon dioxide directly from the ambient air, and then storing it either underground or in long-lived products. This new technology is similar to the carbon capture and storage technology used to capture emissions from sources like power plants and industrial facilities. The difference is that direct air capture removes excess carbon directly from the atmosphere, instead of capturing it at the source. It is relatively straightforward to measure and account for the climate benefits of direct air capture, and its potential scale of deployment is enormous. But the technology remains costly and energy-intensive.

DAC technology can deliver large-scale negative emissions by removing carbon dioxide directly from the atmosphere; and air to fuels technology can significantly reduce the carbon footprint of transportation by creating clean synthetic fuels made from air, water and renewable power.[16]

Direct air capture (DAC) is a process of capturing carbon dioxide (CO_2) directly from the ambient air (as opposed to capturing from point sources, such as a cement factory or biomass power plant) and generating a concentrated stream of CO_2 for sequestration or utilization or production of carbon-neutral fuel and wind gas. Carbon dioxide removal is achieved when ambient air makes contact with chemical media, typically an aqueous alkaline solvent,[17] or sorbents.[18] Large-scale DAC deployment may be accelerated when connected with economical applications or policy incentives. DAC is not an alternative to traditional, point-source carbon capture and storage (CCS) but can be used to recapture some emissions from distributed sources, such as some rocket launches.[19] When combined with long-term storage of CO_2, DAC is known as direct air carbon capture and storage (DACCS or DACS).[20] DACCS can act as a carbon dioxide removal mechanism.

The replacement of carbonate in cement allows for the potential absorption of carbon dioxide over concrete lifecycle. MOFs exhibit high CO_2 capacity and selectivity for CO_2,[21] due to their high surface functionality and porosity.[22]

The increase of CO_2 concentration in the atmosphere and fears of resulting catastrophic global climate change have led to increased demand for CO_2 capture and storage (CCS) technologies.[23,24] CO_2 absorption using chemical reaction is a common process in the chemical industry, along with other processes, has been applied in the treatment of industrial gas streams containing acid gases like H_2S, NOx, and CO_2. In these gas-treating processes, aqueous amine solutions are most commonly used, especially monoethnolamine (MEA), diethanolamine (DEA).[25]

5) Carbon mineralization

Carbon mineralization is the process by which carbon dioxide becomes a solid mineral, such as a carbonate. It is a chemical reaction that happens when certain rocks are exposed to carbon dioxide. The biggest advantage of carbon mineralization is that the carbon cannot escape back to the atmosphere.[26]

Mineralization some minerals naturally react with CO, turning carbon from a gas into a solid. The process is commonly referred to as carbon mineralization or enhanced weathering, and it naturally happens very slowly, over hundreds or thousands of years. Scientists are figuring out how to speed up the carbon mineralization process, especially by enhancing the exposure of these minerals to CO in the air or ocean.

Technologies to capture current CO_2 emissions, reuse and store CO_2 continue to be developed. One of the common themes across these different technologies is the role of inorganic solid carbonate transformations using anthropogenic CO_2 and the development of predictive controls over these pathways. CO_2 conversion to solid inorganic carbonates, also known as carbon mineralization, is a thermodynamically downhill route that can be adapted for integration with CO_2-emitting energy and resource generating processes.[27]

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6) Ocean-Based Carbon Capture

Based carbon removal concepts have been proposed to leverage the ocean's capacity to store carbon and identify approaches beyond only land-based applications. However, nearly all of them are at early stages of development and need more research, and in some cases pilot testing, to understand whether they are appropriate for investment given potential ecological, social and governance impacts. Each approach aims to accelerate natural carbon cycles in the ocean.

They could include leveraging photosynthesis in coastal plants, seaweed or phytoplankton; adding certain minerals to increase storage of dissolved bicarbonate; or running an electric current through seawater to help extract CO. Some ocean-based carbon removal options could also provide co-benefits. For example, coastal blue carbon and seaweed cultivation could remove carbon while also supporting ecosystem restoration, and adding minerals to help the ocean store carbon could also reduce ocean acidification.

The ocean covers about 70% of the Earth's surface and already buffers a large fraction of anthropogenic CO_2 emissions. The global capacity for natural carbon sequestration is in the ocean. Natural processes on land and ocean have removed roughly 55% of emitted CO_2, but it may be possible to enhance both the uptake and longer-term sequestration potential of these processes.[28] But now a growing number of researchers, companies and even national governments have begun to look at the ocean as a potential location for carbon dioxide removal. These approaches aim to leverage the ocean's natural chemical and biological processes to absorb and store more carbon from the atmosphere.[29]

7) Biochar

Biochar is created by the pyrolysis of biomass and is under investigation as a method of carbon sequestration. Biochar is a pyrolyzed product of biomass, is richer in aromatic carbon (C) and poorer in oxygen which provides structural recalcitrance to it against microbial decomposition in soil. Biochar, being a stable source of C when applied to soil, remains there for longer period of time imparting long-term soil C sequestration.

Biochar is a charcoal that is used for agricultural purposes which also aids in carbon sequestration, the capture or hold of carbon. It is created using a process called pyrolysis, which is basically the act of high temperature heating biomass in an environment with low oxygen levels. What remains is a material known as char, similar to charcoal but is made through a sustainable process, thus the use of biomass. Biomass is organic matter produced by living organisms or recently living organisms, most commonly plants or plant based material. A study done by the UK Biochar Research Center has stated that, on a conservative level, biochar can store 1 gigaton of carbon per year. With greater effort in marketing and acceptance of biochar, the benefit could be the storage of 5–9 gigatons per year of carbon in biochar soils.[30] Multiple independent estimates show that biochar has a mean residence time in soils on the order of 1300 to 4000 years.[31]

The matter degradation is very rapid due to constantly high temperatures and moisture levels. In Australia estimates of mean residence time for naturally biochar carbon are 1300 – 2600 years.[32] Biochar is stable, fixed, and recalcitrant carbon can store large amounts of greenhouse gases in the ground centuries, potentially sequester carbon in the soil for hundreds to thousands of years, like coal.[33] Carbon negative technology would lead to a net withdrawal of CO_2 from atmosphere.

Madejski [34] descripted that just four different ways to reduce CO_2 emission level:

(1) reducing the use of fossil fuel by

- improving the efficiency of energy conversion processes.
- reducing the demand for energy
- using renewable energy sources, such as hydropower, wind, biomass, solar cell and nuclear power
- Increasing the use green hydrogen energy

(2) Replace technologies using fossil fuels with a low carbon to hydrogen.

(3) Capturing CO_2 from fuel combustion in power plants and other industrial processes.

(4) Limiting deforestation processes and thus storing more CO_2 in biomass.

IV. Carbon Sequestration

Carbon sequestration is the long-term storage of carbon in plants, soils, geologic, and the ocean. Carbon sequestration is secures carbon dioxide to prevent it from entering the Earth's atmosphere. The idea is to stabilize carbon in solid and dissolved forms so that it doesn't cause the atmosphere to warm.

Carbon is found in all living organisms and is the major building block for life on Earth. Carbon exists in many forms, predominately as plant biomass, soil organic matter, and as the gas carbon dioxide (CO_2) in the atmosphere and dissolved in seawater. Carbon sequestration is the long-term storage of carbon in oceans, soils, vegetation (especially forests), and geologic

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue VII, July 2024

formations. Although oceans store most of the Earth's carbon, soils contain approximately 75% of the carbon pool on land, three times more than the amount stored in living plants and animals. Therefore, soils play a major role in maintaining a balanced global carbon cycle.[35]

The primary way that carbon is stored in the soil is as soil organic matter (SOM). SOM is a complex mixture of carbon compounds, consisting of decomposing plant and animal tissue, microbes (protozoa, nematodes, fungi, and bacteria), and carbon associated with soil minerals. Carbon can remain stored in soils for millennia, or be quickly released back into the atmosphere. Climatic conditions, natural vegetation, soil texture, and drainage all affect the amount and length of time carbon is stored.[36]

Removing CO_2 from the atmosphere is only one significant benefit of enhanced carbon storage in soils. Improved soil and water quality, decreased nutrient loss, reduced soil erosion, increased water conservation, and greater crop production may result from increasing the amount of carbon stored in agricultural soils. Management techniques, which are successful in providing a net carbon sink in soils.[3]

High levels of fossil fuel combustion and deforestation have transformed large pools of fossil carbon (coal and oil) into atmospheric carbon dioxide. Strategies aimed at reducing CO_2 in the atmosphere include soil carbon sequestration, tree planting, and ocean sequestration of carbon. Other technological strategies to reduce carbon inputs include developing energy efficient fuels, and efforts to develop and implement non-carbon energy sources. All of these efforts combined can reduce CO_2 concentrations in the atmosphere and help to alleviate global warming.[38]

Carbon as forests grow, they store carbon in woody tissues and soil organic matter. The net rate of carbon uptake is greatest when forests are young, and slows with time. Old forests can sequester carbon for a long time but provide essentially no net uptake. When forests are cut, the carbon they contain may be quickly returned to the atmosphere if the woody tissue is burned or converted to products, such as paper, that are short-lived. If the wood is used for construction or furniture, then those products retain carbon during their lifetimes and act as carbon sinks. A post harvest approach that reduces waste and puts most of the wood into long-lived products is an effective strategy to help reduce global atmospheric carbon. However, the net sink for carbon in long-lived wood products is still relatively small, so forest cutting ultimately acts to reduce the storage of carbon on land.[39]

V. Biochar is a Carbon Sequestration

The main reason that biochar is considered to be a direct approach for carbon sequestration is that the carbon in biochar is mainly composed of recalcitrant carbon, which is resistant to degradation by microorganisms and can persist in the environment for hundreds or even thousands of years.[40,41]

Carbon sequestration refers to the capture and long-term storage of atmospheric carbon dioxide (CO_2), a major greenhouse gas contributing to global warming and climate change. In recent decades the production and use of biochar has been considered as a strategy for reducing the levels of carbon dioxide in the atmosphere. This can potentially be achieved in direct and indirect ways.

The main reason that biochar is considered to be a direct approach for carbon sequestration is that the carbon in biochar is mainly composed of recalcitrant carbon, which is resistant to degradation by microorganisms and can persist in the environment for hundreds or even thousands of years. By converting biomass into biochar, the carbon in the biomass is stabilized and locked away, preventing it from being rapidly released back into the atmosphere as CO_2 which would otherwise be the case as the biomass feedstock is consumed or decomposes. Hence, providing that the biomass that is used to produce the biochar is replenished. The net effect of growing biomass for the production of biochar is that the atmospheric CO_2 is sequestered in the soil in a stable form.

Biochar can potentially indirectly reduce anthropogenic greenhouse gas emissions by improving soil quality through its enhancement of nutrient and water retention. This results in a reduction in the acidity of the soil and provides a more favourable habitat for beneficial soil microorganisms. These improvements can increase agricultural productivity and potentially reduce the need for synthetic fertilizers, a source of greenhouse gas emissions.

Bochar production and mixing in soil are seen as the best options for atmospheric carbon sequestration, providing simultaneous benefits to soil and opportunities for distributed energy generation. The proximity of biomass source and biochar dispersal greatly reduces the energy and emissions footprint of the whole process. The viability of the whole biochar process is examined from two boundary points: is there enough biomass around to have significant impact on the atmospheric CO_2 levels and is there enough soil area for biochar dispersal.[42]

Biochar is comprised of recalcitrant carbon resistant to microbial degradation, thus contributes to environmental sustainability (ES) through carbon sequestration. Production of biochar from crop residue offers an environmentally safe alternative to avoid open-field crop residue burning. Its application to soil reduces greenhouse gas emissions and acts as a beneficial soil ameliorant. Although literature is available on climate change abatement benefits of biochar application in agriculture, this manuscript explores the benefits of biochar addition in vegetable cropping systems for maintenance of edaphic properties that govern soil sustainability.[43]

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Only carbon removal can balance hard-to-abate emissions and get us to the required net-zero emissions scenario. Biochar Carbon Removal (BCR) is an innovation with game-changing potential. From its carbon removal capabilities to the vast array of co-benefits it offers, BCR is set to become an essential part of any carbon removal portfolio.

When biochar is incorporated into construction materials such as concrete, it becomes an integral part of the material, effectively preventing its physical separation and degradation. As a result, biochar used in construction contributes to long-term carbon removal.

Creating biochar reduces CO_2 in the atmosphere because the process takes the carbon-neutral process of decomposing organic matter and turns it carbon-negative: Plants absorb and store $C0_2$ as they grow but emit this back when they decay. Biochar stabilizes that carbon in a biologically unavailable form, sequestering it out of the atmosphere and into the soil for potentially hundreds or even thousands of years.[44]

Five key issues closely related to the application of biochar for C sequestration in soil and review its outstanding advances. Specifically, the terms use of biochar, pyrochar, and hydrochar, the stability of biochar in soil, the effect of biochar on the flux and speciation changes of C in soil, the emission of nitrogen-containing greenhouse gases induced by biochar production and soil application, and the application barriers of biochar in soil are expounded.[45]

VI. Carbon Balance

The goal of reducing of CO_2 is to make the concentration of CO_2 in atmosphere is not increase. The increasing of CO_2 concentration in atmosphere may cause the increasing of atmosphere temperature, it's may cause global warming and climate change. To avoid the global warming and climate change the concentration of CO_2 in atmosphere is not change drastically, the CO_2 input output into atmosphere should be in balance condition.

This waste could be oxidized to resupply CO_2 to the plants, but this would not be needed unless the system were highly closed with regard to food. For example, in a partially closed system where some of the food is grown and some is imported, CO_2 from oxidized waste when combined with crew and microbial respiration could exceed the CO_2 removal capability of the plants.[46]

The Carbon Balance tool allows to estimate the saving in CO_2 emissions expected. The basis of this calculation are so-called Life Cycle Emissions (LCE), which represent the emissions of CO_2 associated to a given component or energy amount. These values include the total life cycle of a component or energy amount, including production, operation, maintenance, disposal, etc.

Carbon is in a constant state of movement from place to place. It is stored in what are known as reservoirs, and it moves between these reservoirs through a variety of processes, including photosynthesis, burning fossil fuels, and simply releasing breath from the lungs. The movement of carbon from reservoir to reservoir is known as the carbon cycle.[47]

Carbon can be stored in a variety of reservoirs, including plants and animals, which is why they are considered carbon life forms. Carbon is used by plants to build leaves and stems, which are then digested by animals and used for cellular growth. In the atmosphere, carbon is stored in the form of gases, such as carbon dioxide. It is also stored in oceans, captured by many types of marine organisms. Some organisms, such as clams or coral, use the carbon to form shells and skeletons. Most of the carbon on the planet is contained within rocks, minerals, and other sediment buried beneath the surface of the planet.[48]

Because Earth is a closed system, the amount of carbon on the planet never changes. However, the amount of carbon in a specific reservoir can change over time as carbon moves from one reservoir to another. For example, some carbon in the atmosphere might be captured by plants to make food during photosynthesis. This carbon can then be ingested and stored in animals that eat the plants.[49]

When the animals die, they decompose, and their remains become sediment, trapping the stored carbon in layers that eventually turn into rock or minerals. Some of this sediment might form fossil fuels, such as coal, oil, or natural gas, which release carbon back into the atmosphere when the fuel is burned.[50]

The carbon cycle is vital to life on Earth. Nature tends to keep carbon levels balanced, meaning that the amount of carbon naturally released from reservoirs is equal to the amount that is naturally absorbed by reservoirs. Maintaining this carbon balance allows the planet to remain hospitable for life. Scientists believe that humans have upset this balance by burning fossil fuels, which has added more carbon to the atmosphere than usual and led to climate change and global warming.[51]

Humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century. A portfolio of technologies now exists to meet the world's energy needs over the next 50 years and limit atmospheric CO_2 to a trajectory that avoids a doubling of the preindustrial CO_2 concentration.[52] A "wedge" is an activity reducing the rate of carbon build-up in the atmosphere that grows in 50 years from zero to 1.0 giga ton of carbon (GtC)/year.

It is thought that limit atmospheric CO_2 to a concentration that would prevent most damaging climate change have focused on a goal of 500 ± 50 parts per million (ppm). The current CO_2 concentration is 375 ppm.[1] A stabilization wedge represents an activity that starts at zero reduction of emission in 2005 and increases linearly until it accounts for 1 GtC/year of reduction carbon emissions in 2055. Each wedge is represents a cumulative total of 25 GtC of reduced emissions over 50 years.[53] The current

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue VII, July 2024

technology to provide a wedge is used fuel with low carbon contain. A total of seven wedges are required to stabilise emissions at 500 ppm CO_2 in fifty years.

When biochar is inserted in soil, the effect is to remove carbon from the atmosphere and store it underground, where it does not contribute to global warming. The largest outstanding question about biochar is how much of a difference it can make in slowing global warming.[54] Biochar, has calculated that if biochar were added to 10 percent of global cropland, the effect would be to sequester 29 billion tons of CO_2 equivalent, it's roughly equal to humanity's annual greenhouse gas emissions.[33] Maintaining the emission of carbon in the year of 2055 similar the emission in the year 2005 we must store carbon as amount as 7 wedges.[52]

Biochar can be produced from biomass waste that is good for environment. Production of biomass to achieve the amount equal to 1 GtC is great amount of biomass to be produced. In agricultural and forest industries produced of biomass waste in great amount.[55] Conversion of biomass waste into carbon, carbon sequestration was explained by Stoyle.[56]

Conclusion

Carbon element in the earth is closed system that the amount of carbon is not change, but the carbon formula is different in chemical formula. Carbon can be form in many formulas such as of CO_2 in atmosphere, carbon is a C form as chars, carbon is in the plants and animals tissue, carbon is a CO_2 form as a dissolved in the ocean, carbon is a CO_2 dissolved in the soil, C in the rocky form such as $CaCO_3$, $MgCO_3$, C in the form of organic chemical such as organic chemical, C in the form of fossil oil and gas. Carbon in the form of element is different concentration to each other sometime high and sometime lower.

The CO_2 enter and out into atmosphere were called carbon positive and negative. Carbon positive and negative should be in balance to maintain the CO_2 concentration in atmosphere. To maintain the carbon balance in the atmosphere is a complex reaction that the speed of reaction is not in the same in each reaction. Nowadays, the burning fuel is the most the carbon positive added to the atmosphere.

There is a current technologies of stabilization wedges that solving the climate problem for the next 50 years. Limit atmospheric CO_2 to a concentration of 500 ppm. Targets for CO_2 emission of 500 ppm was maintaining with reducing emissions at 7 wedges.

References:

1. Anon1, 2015. Trends in Atmospheric Carbon Dioxide. National Oceanic & Atmospheric Administration 2015
2. Lindsey, R. 2022. Climate Change: Atmospheric Carbon Dioxide. June 23,2022. https://climate. gov/media/13611.
3. Anon2, 2022. Carbon dioxide now more than 50% higher than pre-industrial levels. National Oceanic & Atmospheric Administration, US Department of Commerce, 3 June 2022.
4. Kirtman, B. Power, S.B, Adedoyin, J.A., Boer, G.J, Bojarin, R., Camilloni, I, Doblas Reyes, F.J., Fiore, A.M., Kimoto, M., Meehl, G.A. et al. Chapter 11: Near-Term Climate Change: Projections and Predictability. Clim. Change. 2013. Phys. Sci. Basis. Contrib. Work. Gr. I to Fifth Assess. Rep. Intergov. Panel Clim.Chang.2013, No. June,953-1028.
5. EPA, 2013. U.S. EPA. Report on the 2013 U.S. Environmental Protection Agency (EPA) International Decontamination Research and Development Conference. Research Triangle Park, NC, November 05 - 07, 2013. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-14/210, 2014.
6. Zhai, Y., Wang, S. and Chuang, S. 2019. The nature of Hydrogen Bonding in Adsorbed CO_2 and H_2O on Solid Amines in CO_2 Capture. Catalysis Series, 36, 503-526
7. Feygina, I., Jost, J.T. and Goldsmith, R.E. 2010. System Justification, the Denial of Global Warming, and the Possibility of" System Sanctioned Change", New York University, Feb. 28.
8. Selin, N.E. 2024. Carbon sequestration. The Encyclopaedia Britannica, Updated: Apr 26, 2024
9. Mulligan, J., Ellison, G., Levin, K., Lebling, K. and Rudee, A. 6 Ways to Remove Carbon Pollution from the Sky. World Resources Institute. June 9, 2020.
10. Hellmers, H. 1964. An evaluation of the photosynthetic of efficiency of Forests. In The Quarterly Review of Biology, vol.39, No, 3: pp.249-257.
11. Schumer, C. and Lebling, K. 2022. How are Countries Counting on Carbon Removal to Meet Climate Goals? World Resources Institute, 40 Years. March 16, 2022.
12. Vujasin, M. 2022. Soil carbon storage in agriculture for climate and trade, bonds and profits. Balkan Green Energy News. November 6, 2022.
13. Gattinger, A., Muller, A., Haeni, M., Skinner, C., Fliessbach, A., Buchmann, N., … & Niggli, U. (2012). Enhanced topsoil carbon stocks under organic farming. Proceedings of the National Academy of Sciences, 109(44), 18226-18231.
14. Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. science, 304(5677), 1623-1627.
15. Cheah, W.Y., Show, P.L., Chang, J-S., Ling, T.C. and Juan, J.C. 2015. Bio sequestration of atmospheric CO2 and flue gas-containing CO2 by microalgae, Biresour. Technol, 184,190-201, doi: 10.1016/j.biortech.2014.11.026
16. St. Angelo, D. 2020. Direct Air Capture: Capturing Carbon Dioxide Directly from the Atmosphere. Proceeding: 2020 Virtual AIChE Annual Meeting. Session: Carbon Dioxide Capture Technologies and Their Use.
17. Keith, D.W., Holmes, Geoffrey, H., St. Angelo, D. and Kenton, H.2018. "A Process for Capturing CO_2 from the Atmosphere" (https://doi.org/10.1016/Fj.joule.2018.05.0 06). Joule. 2 (8): 1573–1594.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue VII, July 2024

18. Christoph, B., Charles, Louise, C., Wurzbacher, J. 2019. "The Role of Direct Air Capture in Mitigation of Anthropogenic Greenhouse Gas Emissions". Frontiers in Climate. 1: 10. doi:10.3389/fclim.2019.00010.
19. Katharine, G. 2021. How the billionaire space race could be one giant leap for pollution. The Guardian. Retrieved July, 26, 2022.
20. Christoper, Q.J. and Sheila, S. 2020. The value of hydrogen and carbone capture, storage and utilization in decarbonizing energy: Insights from integrated value chain optimization. Applied Energy, 257: 113936, doi: 10.1016/j. apenergy. 2019.113936
21. Sumida, K.; Rogow, D. L.; Mason, J. A.; McDonald, T. M.; Bloch, E. D.; Herm, Z. R.; Bae, T.-H.; Long, J. R. 2012. Carbon Dioxide Capture in Metal–Organic Frameworks. Chem. Rev, 112 (2), 724-781.
22. Suh, M. P.; Park, H. J.; Prasad, T. K.; Lim, D.-W. 2012. Hydrogen Storage in Metal–Organic Frameworks. Chem. Rev. 112 (2), 782-835.
23. Miller, MB., Bing, W., Luebke, DR. and Enick, RM. 2012. Solid CO2-philes as potential phase-change physical solvents for CO_2. J Supercrit Fluids; 61:212e20.
24. Kim, SH., Kim, KH. and Hong, SH. 2014. Carbon dioxide capture and use: organic synthesis using carbon dioxide from exhaust gas. Angew Chem Int, Ed;53:771e4. 20 Chapter 1.
25. Kato, Y., Murai, S., Muraok, D., Muramatsu, T. and Saito, S.2013. Evaluation of carbon dioxide absorption by amine based absorbent. Energy Procedia, vol.37: 325-330, doi: 10.1016/j.egypro.2013.05.118
26. Blondes, M.S. 2019. Making minerals- How growing rocks can helps reduce Carbon Emissions. USGS, Communications and Publishing, Marck 8, 2019.
27. Gadikota, G. Designing multiphase carbon mineralization pathways for the reactive separation of CO_2 and directed synthesis of H_2. Nat. Rev. Chem. 4, 78–89 (2020)
28. Doney, S. 2021. A Research Strategy for Ocean Carbon Dioxide Removal and Sequestration. National Academics. Science, Engineering, Medicine. Desember 8, 2021.
29. Lebling, K., Northrop, E. and McCormick, C. 2022. Ocean-based Carbon Dioxide Removal: 6 Key Questions, Answered. World Resources Institute, Nov.,15, 2022
30. Matovic, D. 2010. Biochar as a viable carbon sequestration: Global and Canadian perspective. Energy, doi: 10.1016/j.energy.2010.09.03
31. Cheng, CH., Lehmann, J. and Engelhard, M. 2008. Natural oxidation of black carbon in soils: changes in molecular form and surface charge along a climosequence. Geochimia et Cosmochimica Acta, 72, 1598- 1610
32. Lehmann, C.J., Czimczik, C., Lahird, D. and Sohi, S. 2009. Stability of Biochar in the Soil. In: Lehmann, C.J., Joseph, S. (Eds). Biochar for Environmental management: science and technology, Earthscan.
33. Madejski, P., Chmiel, K., Subramanian, N. and Kus, T. 2022. Methods and Techniques for CO_2 capture Review of Potential Solutions and Applications in Modern Energy Technologies. Energies, 15, 887. Doi: 10.3390/en15030887.
34. Gupta, D., Kumar, C., Dubey, R. and Fagodiya, R.K. 2020. Role of Biochar in Carbon Sequestration and Greenhouse Gas Mitigation. April 2020, In book: Biochar Applications in Agriculture and Environment Management (pp.141-165), DOI:10.1007/978-3-030-40997-5_7.
35. Giannetta, B., Plaza, C., Cassetta, M., Mariotto, G., Benavente-Ferraces, I., García-Gil, J.C., Panettieri, M. and Zaccone, C. The effects of biochar on soil organic matter pools are not influenced by climate change. J. Environmental Management, vol. 341:118092, doi:10.1016/jevrment.2023.118092.
36. Paustian, K., Larson, E., Kent, J., Marx, E. and Swan, A. 2019. Soil C Sequestration as a Biological Negative Emission Strategy. REVIEW article, Front. Clim., 16 October 2019, Sec. Carbon Dioxide Removal Volume-1, 2019, https://doi.org/10.3389/fclim.2019.00008
37. Ritchie, H. 2020. "What are the safest and cleanest sources of energy?" Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/safest-sources-of-energy' [Online Resource].
38. Waring, B., Neumann, M., Prentice, I.C., Adams, M., Smith, P. and Siegert, M. 2020. Forests and Decarbonization – Roles of Natural and Planted Forests. Front. For. Glob. Change, 08 May 2020, Sec. Forests and the Atmosphere Volume 3 - 2020 | https://doi.org/10.3389/ffgc.2020.00058
39. Sohi, S.P., Krull,E., Lopez-Capel, E. and Bol, R. 2010. Chapter 2. A Review of biochar and its use and Function in Soil, In D.L. Sparks, editor: Advances in agronomi, vol. 105, Burlington: Academic Press, pp: 47-82
40. Ameloot, N., Graber, E.R., Verheijen, F.G.A. and De Neve, S. 2013. Interactions between biochar stabilility and soil organisms: Review and research needs. E, J, of Soil Science, 64:379-390, doi: 10.1111/ejss. 12064.
41. Motovic, D. 2011. Biochar as a viable carbon sequestration option: Global and Canadian perspective. Energy, vol. 36, Issue 4: 2011-2015, doi: 10.1016/j.energy.2010.09.031.
42. Sharma, S.P. 2018. Biochar for Carbon Sequestration: Bioengineering for Sustainable Environment. Omics Technologies and Bio-Engineering, Volume 2: Towards Improving Quality of Life 2018, Pages 365-385, doi: 10.1016/B978-0-12-815870-8.00020-6
43. Woo, C. 2022. Biochar Land Carbon Sequestration: a benefit or a bother? Enviroment Institute. Published on 31Oktober 2022.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIII, Issue VII, July 2024
44. Luo, L., Wang, J., Lv, J., Liu, Z., Sun, T., Yang, Y. and Zhu. Y-G. 2023. Carbon Sequestration Strategies in Soil Using Biochar: Advances, Challenges, and Opportunities. Environ. Sci. Technol. 2023, 57, 31, 11357–11372, doi: 10.1021/acs.est.3c02620.
45. Wheeler,R.M. 2003. Carbon balance in bioregenerative life support systems: some effects of system closure, waste management, and crop harvest index. Adv Space Res. 31(1): 169-175, doi:10.1016/s0273-1177(02)00742-1
46. Anon-3, The Carbon Cycle. National Geographic.
47. Keller, P.S., Merce, R., Obrador, B. & Koschorreck, M. 2021. Global carbon budget of reservoirs is overturned by the quantification of drawdown areas. Nature Geoscience, 14: 402-408.
48. Winkler, A.J., Myneni, R.B., Alexandrov, G.A. & Brovkin, V. 2019. Earth system models underestimate carbon fixation by plants in the high latitudes. Nature Communications, volume 10, Article number: 885 (2019).
49. Bobrowsky, M. 2019. Where do fossil fuel come from? NSTA, Oktober 2019.
50. Putsep, A. 2021. The Carbon Cycle Explained: The Delicate Balance of Carbon in the Atmosphere, Science & Tech, May 4, 2021.
51. Pacala, S., and Socolow, R., (2004). Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. Science, 205: 968 – 972, DOI: 10.1126/science.1100103
52. Hotinski, R. 2006. The ImpEE project. Stabilisation Wedges: Solving the Climate Problem for the next 50 years with current Technologies. CMI Information Officer, Princeton Environmental Institute, Princeton University, hotinski@princeton.edu. http://www.princeton.edu/-cmi.
53. Hertsgaard, M.2014. As Uses of Biochar Expand, Climate Benefits Still Uncertain. Environment 360, 21 Jan. 2014.
54. Bailis, R., Ezzati, M., and Kammen, D.M., (2005). Mortality and greenhouse gas impacts of biomass and petroleum energy futures in Africa, Science, 208, 98 – 103.
55. Stoyle, A. (2011). Biochar production for carbon sequestration. Bachelor Thesis of science in Chemical Engineering. Shanghai Jiao Tong University, China