Journal of Climatology & Weather Forecasting 2022, Vol. 10, Issue 12, 001-003 Opinion

The Increase of Soil Organic Matter Reduces Global Warming, Myth or Reality

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Received: 07-Dec-2022, Manuscript No. JCWF-23-24541**; Editor assigned:** 09-Dec-2022, Pre QC No**.** JCWF-23-24541 (PQ); **Reviewed:** 23-Dec-2022, QC No. JCWF-23-24541 (Q); **Revised:** 28-Dec-2022, Manuscript No. JCWF-23-24541 (R); **Published:** 31-Dec-2022, DOI: 10.35248/2332-2594.22.10(12).341

Abstract

Over the years, the earth has lost organic substance. One of the management techniques used to restore the historical levels of soil carbon is adding organic matter to soils. Is it wise to try to stop global warming? In actuality, one of the methods pushed to fight climate change growing the organic content of the soil. However, adding organic waste to the soil might make it easier for CO_2 to be released, and wastes might also have no beneficial impact on the characteristics of the soil. In this regard, it is crucial to understand the expected effects of adding organic matter to the soil, how this application alters soil processes, the management practices that should be used, the actual amount of carbon sequestered by the soil, and the balance both immediately after the application and over a longer period of time. The best course of action would be to encourage the growth of biologically stabilized soil organic matter throughout the medium and long term.

Keywords: Carbon stock• Climate change • humus • Organic wastes•

Introduction

The amount of organic matter today is governed by the balance between the rates of organic carbon input and outflow since soils now play a significant role in the global carbon cycle. The total amount of organic carbon compounds supplied to the soil over a given period of time, often a year, is the carbon input. It comprises of organic carbon found in wastes and manure, as well as carbon from agricultural residues, dying roots, and other sources. Storage and a potential decrease in atmospheric carbon are both involved in carbon uptake in soil. Environmental considerations (climatic factors), soil type, and transformation processes, including biological interactions, all affect carbon storage. Several elements of nature affect temperature, soil moisture and water saturation, texture, topography, salt, acidity, vegetation, and biomass production all affect how much organic matter is in the soils. Additionally, it is acknowledged that management practices are crucial in determining the carbon content of soils The Food and Agricultural Organization of the United Nations (FAO) has launched a programme on SOC mapping to assist nations and enhance soil governance at the global, regional, and national levels in recognition of the need to protect soil resources from degradation and promote healthy soils. A increasing need for current soil carbon data for global climatic and environmental models has emerged in recent years due to soils' importance as the largest terrestrial carbon pool and their importance in the regulation of climate change processes. In light of the aforementioned factors, increasing soil organic matter, especially in the topsoil (0–30 cm depth), is a desirable goal for sustainability and the fight against global warming. But this assumption needs to be qualified. Soil Organic Matter (SOM) was defined by Baldock and Skjemstad (1999) as all organic components present in soils, regardless of origin or state of decomposition. These comprise a wide range of organic molecules linked to numerous diverse mechanisms and processes involving all soil components (mineral, organic, and biological fractions), as well as soil organic materials that were contributed by humans. In order to secure the storage of organic carbon in soil profiles, it is crucial to consider the kind of organic matter and its stability. The average estimate for the amount of Organic Carbon (OC) in soil is 58%, and in most circumstances, this amount can be accurately quantified. On the other hand, many soil properties connected to SOM, such as water holding capacity, aggregate stability, compaction characteristics and friability, soil erodibility, nutrient cycling, cation exchange capacity, and acidification buffering capacity, among others, are influenced by the amount of carbon stock and the type of SOM. The cycles of important plant nutrients like N, P, or S are also fundamentally dependent on SOM. This indicates that in order to enhance mineral plant nutrition and biomass growth, SOM should be degraded and mineralized. When it comes to soil characteristics, organic matter formation happens quickly, but weathering usually happens more slowly. The kind and amount of organic matter can change, changing the properties of the soil.

Carbon stored in soils

We should keep in mind that it is challenging to pinpoint exactly where carbon is stored in the environment, and it goes without saying that soil, a highly dynamic system, is no exception. The carbon supply in soil has, nevertheless, been the subject of extensive research. Batjes (1996) claims that the top 1 m of soil has 1500 Gt SOC, with the top 30 cm containing nearly half of this amount. According to Lal's article from 2004, the total amount of soil carbon (C) in the world is around 2500 gigatons (Gt), of which 950 Gt is Soil Inorganic Carbon (SIC) and 1550 Gt is soil organic carbon (SOC). The total of inputs and losses from the soil determines the amount of SOM, however soil management is crucial to regulating inputs. According to Lal (2004), the conversion of natural to agricultural ecosystems results in a depletion of the SOC pool of up to 60% in temperate soils and up to 75% or more in tropical cultivated soils. This suggests that human-driven land-use decisions have significantly decreased the global SOC level, with losses of 133 Pg (C) at 2 m soil depth. It is evident that when agriculture became more intensive over the 20th century, many soils' organic carbon concentrations decreased as a result .If soil carbon has been declining for the past few years in the majority of soils, increasing SOM by the addition of organic matter through natural or human-induced processes (the application of wastes and other organic amendments) appears to be an effective technique to prevent global warming. If the carbon store rises, increasing SOC might result in less carbon in the atmosphere. However, the type of soil and the surrounding environment would encourage the release of carbon compounds into the atmosphere. We are at a decision point when we are unsure of which course of action is best: whether to add organic materials or not. The type of organic matter and the soil's environmental factors could affect the solution. Numerous studies have been conducted to estimate carbon stocks, but we may accept the world average value of 1500 Gt for the SOC pool in the first 1-2 m even though some of the methodologies used to estimate the SOC lead to systematic overestimation. According to the Global Soil Organic Carbon Map, the top 30 cm of soil hold roughly 680 billion tonnes of carbon, which is approximately twice as much as what is found in our atmosphere. When compared to the carbon stored in all of the vegetation (560 billion tonnes), this quantity is significant.

Carbon storage and soil conditions

Many governments and international organizations are beginning to acknowledge the benefits and services that soils offer to society, but not the general public. According to the EU, one of the main variables influencing soil formation is the temperature, but soils are also crucial for preventing climate change since they can store organic carbon. As soils have a limited ability to store carbon and have a limit on the buildup of organic matter, the type of soil affects the potential storage of carbon. Clay and silt particles help to stabilize SOC in mineral soils by adsorbing to them (creating clay-humic complexes).However, there are limits to how much carbon may be found in clay and silt. Additionally, the climate and soil-presented microorganisms have a significant impact on the degradation of SOM and gas emissions.

The proportion of mineral soils in Europe with low or very low organic carbon contents (0–2%) and medium contents (2–6%) should be taken into account. This information suggests that soils all over Europe are probably storing carbon. The type of organic matter added to raise the soil's carbon content and the environmental factors that affect the soil also play a role in how much SOM accumulates in the soil. As a result, we must remember that SOM accumulation and addition do not equate to the occurrence of carbon sequestration and storage. However, the latest IPCC report predicts that future net increases in CO_2 emissions from vegetation and soils due to climate change will be offset by enhanced removals due to CO_2 fertilisation and longer growing seasons. The loss of soil carbon is anticipated to increase even with the anticipated thawing of permafrost. The soil's capacity to store carbon has a limit, and depending on the environment, the soil eventually achieves a state of equilibrium where carbon stores can be preserved and annual removal of CO_2 from the atmosphere drops towards zero. Future losses (or sink reversals) of carbon stored in vegetation and soils could result through disturbances including floods, droughts, fires, pest outbreaks, or bad management. Numerous elements that increase or decrease soil's capacity to store carbon and reduce global warming may help to solve the issue. Soil carbon management, in line with IPCC recommendations, may be relevant across a wide range of land use types, not just in agricultural or forest areas. Additionally, the IPCC acknowledged the relationship between environmental and cultural context at local and regional levels and adaptation and mitigation choices and their limitations due to the site-specific nature of climate change impacts on food system components and broad variability in agroecosystems. Each location's socioeconomic environment has a significant impact on soil management, which in turn affects soil's potential to store carbon and its impact on global warming.

Land management and SOM

FAO released Soils Bulletin No. 13 in advance of the Conference on the Human Environment (Stockholm, 1972). According to its executive statement, "it is imperative that adequate attention be given to problems of land degradation because of the rapid increase in the rate of use of the land as a result of pressures from population and technology". Human activity causes soil changes that reduce SOM as a result of the pressure put on land resources. The IPCC provides a precise definition of land degradation as a negative trend in land condition brought on by direct or indirect human-induced processes, such as anthropogenic climate change. There are numerous causes for the decline in SOM, and the majority of them are related to human activity: The following factors contribute to the rapid mineralization of SOM's labile components:

- Conversion of grassland, forests, and other natural vegetation to arable land
- Deep ploughing of arable soils
- Overgrazing with high stocking rates
- Soil erosion by water and wind
- Leaching
- Forest fires

Additionally, urban growth and soil sealing should be taken into account. The organic matter content of the soils is typically one of the most significant factors to consider while studying land degradation. SOC/SOM is generally quite dynamic since it is highly reactive, Because of its low density and proximity to the soil surface, it is preferentially removed by erosional processes, where it serves as a source of energy for all soil bacteria and other biota. This dynamic makes it desirable to apply land management strategies to increase SOM for carbon storage and sequestration, such as better management of crops and grazing lands and sustainable forest management. In actuality, our goal should be to encourage the emergence of humus, or stabilised organic matter, as well as the most stable humus components in soils, such as refractory organic compounds like black carbon. It has been shown that ancient soils preserved organic materials as black carbon (charcoal made from forest fires), a possible agent in the global C cycle. We can infer from the IPCC reports that land-based strategies that result in carbon sequestration in soil or vegetation, such as afforestation, reforestation, agroforestry, soil carbon management on mineral soils, or carbon storage in harvested wood products, do not continue to sequester carbon indefinitely. Peatlands can continue to store carbon for centuries, according to the IPCC. Although the local hydrology and regional climate that have sustained their existence for millennia are under increasing pressure from changes in land use and changes in the Andean climate, Hribljan et al. (2016) worked in the Ecuadorian páramo peatlands and demonstrated that has been accumulating C in their soils for over 7000 years. In almost every region of the world, SOC loss has predominated in terms of the carbon balance of agricultural land, according to the mainstream view. The following factors contribute to SOC loss:

- Less input of above- and below-ground residues by agricultural crops compared to natural vegetation
- Acceleration of SOC decomposition by tillage disturbance that increases microbial oxidation
- Relocation of C input by crops to the upper 20-30 cm soil compared to much deeper roots of native plants;
- Strong erosion.

Best SOM management practices

After commenting on the prior examples, it can be difficult to determine the best practices that can be applied to generally raise the content of SOM. Numerous best management practices, such as no-till, conservation tillage, groundcover and cover crops integrated in grain, forage, and agro-forestry systems, and grassland management, have been identified by scientists as ways to improve soil carbon management, increase carbon sequestration, and ensure long-term productivity. However, in addition to the characteristics of the soil, environmental conditions, social, and economic considerations will determine which of these practices is the most suitable. For instance, as reported by Kämpf et al. (2016), carbon stores were 18% greater in soils of ex-arable land than in arable land. In conjunction with residue application, no-till dramatically changed the soil's mechanical (bulk density, penetration resistance) and hydrological (infiltration rate and saturation hydraulic conductivity) qualities. Additionally, the production of macro-aggregates under long-term conservation tillage and the use of crop residue mulch increase soil carbon concentration. Through an increase in SOC stocks, groundcovers, used as a method to enhance soil properties for cultivation, encourage atmospheric CO_2 sequestration in the soil. According to Garca-Daz et al. (2018), using groundcover in Mediterranean vineyards with damaged soils improves soil quality more than using conventional tillage. Because groundcover receives higher carbon inputs than tillage, it increases soil organic carbon. Additionally, they discovered a rise in stable organic matter in soils linked to mineral fractions. Keeping in mind the goal of maintaining and raising SOM levels, organic stabilised compounds, this result is quite significant. By increasing and maintaining inputs of plant residues, Riu et al. (2016) demonstrated that semi-arid coarse textured soil has additional capacity for soil C storage. Long-term outcomes, however, were hampered by a lack of inorganic nutrients needed to create microbial biomass. These results highlight the challenge of raising the total soil C stock in semi-arid dryland cropping regions through additional plant waste inputs, while effective management of inorganic nutrients must be taken into account for further increase in soil C storage.

Following the Rattan Lal and FAO reports, which focus on the transfer of atmospheric CO_2 into biotic and pedologic C pools, also known as terrestrial C sequestration, the following management practices are advised for agricultural soils:

- Reduced or no mechanical tillage and the use of no-till (NT) or minimum till;
- Use of crop residues or synthetic materials as surface mulch in conjunction with the rotation of cover crops

- Adoption of conservation-effective measures to reduce soil and water losses by surface runoff and accelerated erosion bioengineering
- Improvement of soil fertility through integrated nutrient management (INM) that combines techniques.

In general, land-use conversions from forests to grasslands saw the greatest gains in soil C stocks, and land-use conversions from forests to farms saw the greatest decreases in soil C stocks. Following the conversion of farmland to grassland and forest to grassland, Deng et al. (2016) found that soil C stocks greatly increased, while soil C stocks significantly decreased, following the conversion of grassland to farmland, forest to farmland, and forest to forest. Additionally, soil C sequestration did not alter much after cropland and grassland were converted to forests, which is consistent with the findings of Powers et al.

Conclusions

Despite the controversy over climate change and the underwhelming outcomes from the Conference of the Parties (COP25) conducted in Madrid (2019) regarding soil, the SOC stock has to be increased, enhanced, and restored. Additionally, the resolution 4/CP.23 reached at the COP23 meeting in Bonn in 2017 should be reviewed and taken into consideration.

Cite this article: Daniel. R. The Increase of Soil Organic Matter Reduces Global warming Myth or Reality J Climatol Weath Forecast. 2023, 10 (12), 001-003