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Transforming Sugarcane Industry as a Carbon Sink

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Abstract

The sugar industry is traditionally regarded as a carbon neutral sector because the amount of CO_2 captured during sugarcane growth is roughly equivalent to the amount released during processing. However, as the industry moves toward E20 and E100 fuel blending, ethanol production is rising significantly—generating approximately 40 MT of CO_2 for every 100 KL of ethanol. While pollution control authorities increasingly mandate the capture of this gas, commercial demand in the food and chemical industries remains too limited to absorb the projected surplus. This paper proposes a novel concept to transform the sugar industry into a carbon sink by utilizing captured CO_2 to enhance agricultural yields and reducing CO_2 emission in the process of sugar manufacturing. By bridging the photosynthesis gap through controlled release of CO_2 during peak daylight hours, we can stimulate plant growth and significantly improve soil carbon levels, which have depleted from over 1.5% to less than 0.5% in many regions over the last couple of decades. This approach aims to restore the soil ecosystem, reduce the carbon footprint of sugar processing, and provide a sustainable pathway to double farmers' income while achieving national carbon balance goals.

Keywords: Carbon fixation; Soil carbon; Yield improvement; Enhanced photosynthesis

Introduction

Carbon is the most essential element of life. Photosynthesis is the back bone of entire ecosystem. Overall agricultural sustainability is depended upon soil organic carbon. Due to industrialization huge amount of CO_2 is released to atmosphere from the burning of fossil fuels, cement production. Greenhouse gases have been increasing, average global temperatures have risen 0.8 degrees Celsius since 1880 and we are facing serious problems of global warming now.

Entire ecosystem looks imbalanced and excessive rains / drought situation is making agriculture difficult. We always blame for industrialization, transport industry and energy industry for this. Perhaps one more factor may have been responsible for releasing CO_2 to atmosphere – agricultural practices?

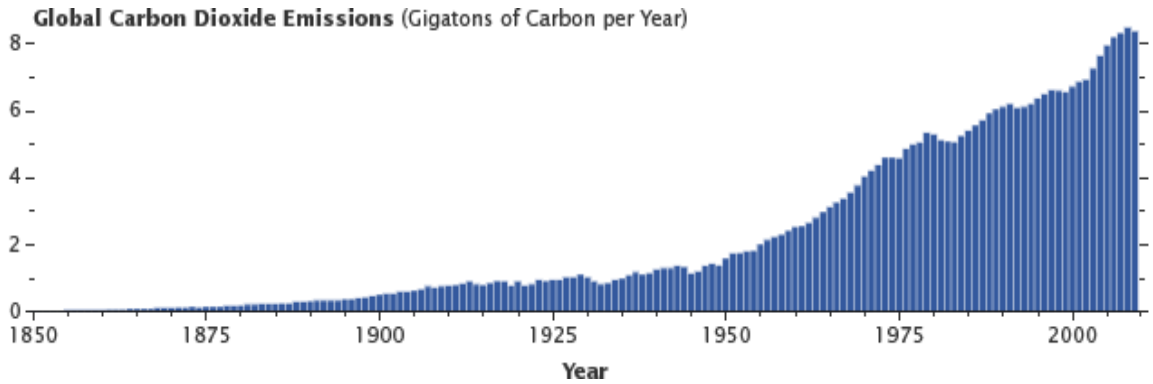

Fig. 1. Emissions of carbon dioxide by humanity (primarily from the burning of fossil fuels, with a contribution from cement production) have been growing steadily since the onset of the industrial revolution. About half of these emissions are removed by the fast carbon cycle each year, the rest remain in the atmosphere. (Graph by Robert Simmon, using data from the Carbon Dioxide Information Analysis Center and Global Carbon Project.)

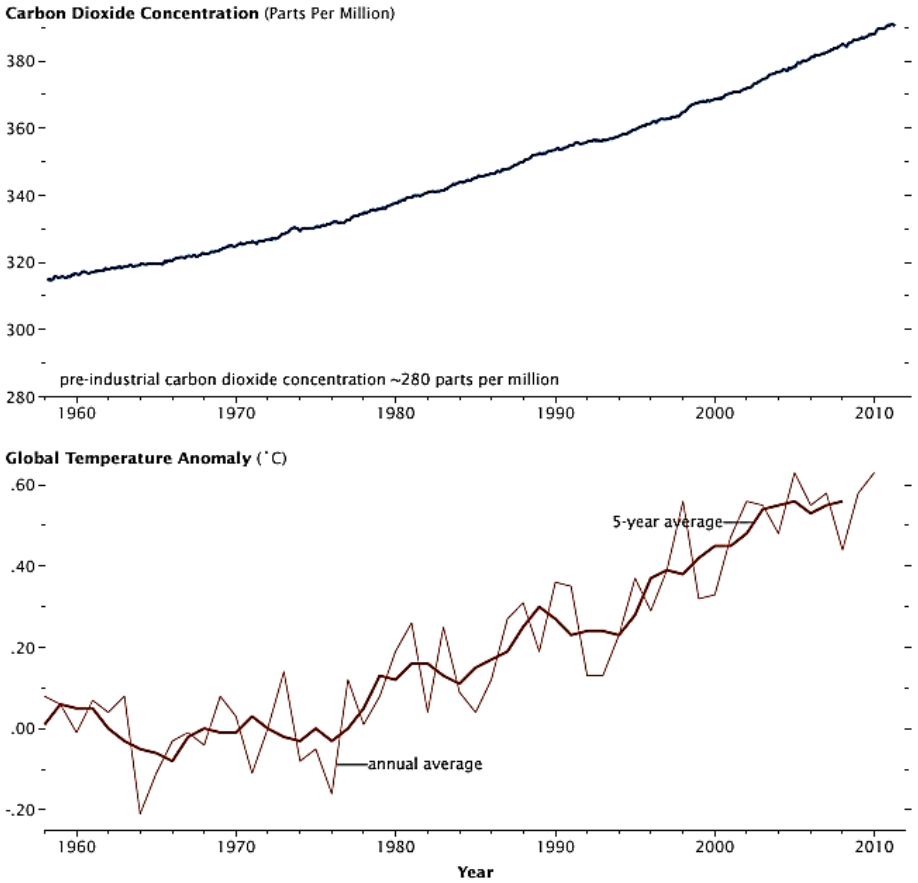

Fig. 2. With the seasonal cycle removed, the atmospheric carbon dioxide concentration measured at Mauna Loa Volcano, Hawaii, shows a steady increase since 1957. At the same time global average temperatures are rising as a result of heat trapped by the additional CO_2 and increased water vapor concentration. (Graphs by Robert Simmon, using CO_2 data from the NOAA Earth System Research Laboratory and temperature data from the Goddard Institute for Space Studies.)

Ethanol Blending in fuel

Thus, it is now essential to control emission of CO_2 immediately. Our government have decided and achieved about 20% ethanol blending in petrol and trials are in advance level for 5% ethanol blending in diesel. This have helped us in reducing oil imports, reducing carbon emissions and supporting our own industry. It would be worthwhile to look at carbon footprint of petroleum fuel and ethanol. Sugarcane alone may not be sufficient to supply huge demand for ethanol and hence our government is promoting ethanol from excessive food grains like broken rice and maize.

The truth about ethanol and carbon emissions

For understanding the true carbon benefits of ethanol, one first need a proper understanding of the carbon footprint associated with producing and using gasoline the fuel that powers most automobiles around the world today. The fuel typically has a lifecycle carbon intensity of about 98.5 grams (g) of CO_2-equivalent greenhouse gases per megajoule (MJ) of energy delivered. When we compare, all of the emissions tied to making and using ethanol are added together, the fuel typically has a lifecycle carbon intensity of about 53.3 g/MJ. Thus, the lifecycle carbon intensity of today's ethanol is about 46 percent lower than gasoline's carbon intensity.

An important feature of ethanol's carbon lifecycle is the fact that combustion emission (i.e. when the fuel is burned in the engine) are near zero. That's because of amount of biogenic CO_2 emitted from the tailpipe when ethanol is burned in the engine is the same amount of CO_2 that was removed from the atmosphere by corn plants at the beginning of the process (Biorefineries also release biogenic CO_2 during fermentation of starch into ethanol).

Agricultural practices can be important factor for this achievement and sugar industry can play significant role in this, especially by utilizing this released CO_2 from ethanol industry. Just about 60 – 70 years ago, our soil used to have soil carbon in excess of 1.5%, now it is significantly less than 0.5%, many fields have even lower carbon >0.2%! Considering just 6-inch soil values of our entire soil and calculating this loss of carbon to atmosphere, we will realize that this is quite huge amount contributing to menace of global warming! Unfortunately, chemical fertilizers do not answer this deficiency, in fact they may have been responsible for this loss of carbon from soil. We are facing problems in yield decline of almost every crop despite of using best of fertilizers, insecticides, pesticides and weedicides for crop protection. This use of chemicals has increased cost of production and have failed to enhance yield to make farming unmanageable. Promoting organic farming or natural farming is not yielding benefits as crop

production can reduce further and farmers have no idea what to do? This can mean that we have destroyed our ecosystem which used to be balanced few decades ago.

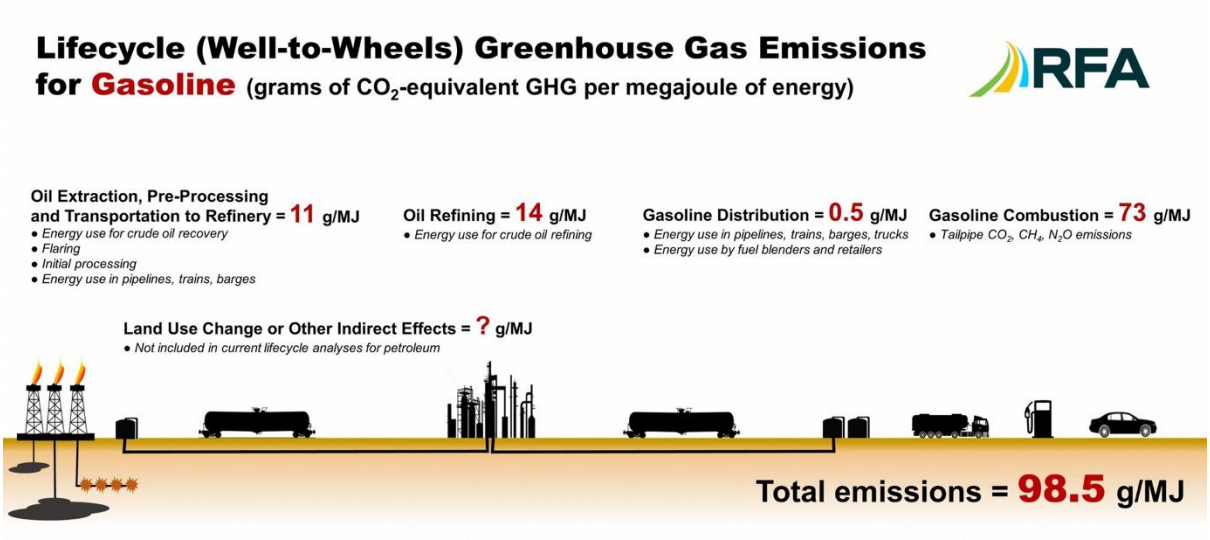

Fig.3. CO_2 emissions by fuel oil

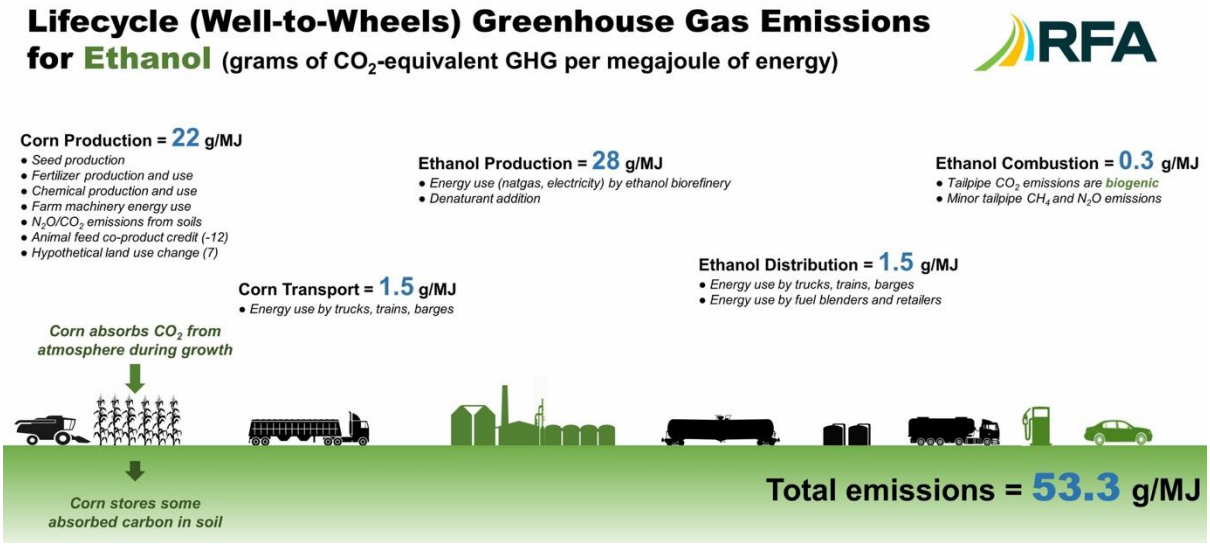

Fig. 4. Life cycle CO_2 emissions by fuel ethanol

Soil as a product of weathered rock in which there is some biological activity. Fertile soil, thus has plenty of microbes balancing each other and have good amount of carbon – more than 2.5%. Such soil supports healthy plantation with good farm produce helping carbon recycling. Soil carbon is essential for supporting microbial life responsible / essential for recycling of all essential elements including Nitrogen, potash, phosphate and sulfur. In short, Healthy Agriculture is not possible without soil carbon. Unless we raise carbon of our soil to more than 1.5%, we can't restore balanced reaction of the ecosystem that used to give all necessary nutrients for our agriculture. If we look at the yields obtained in Green Houses (Glass House or Shed net farming) as compared to normal farming, using these technologies yields are more as CO_2 content in this controlled farming is more!

Photosynthesis – a Key of Organic Chemistry

During photosynthesis, plants absorb carbon dioxide and sunlight to create fuel-glucose and other sugars for building plant structures. This process forms the foundation of the fast carbon cycle.Conversion of CO_2 to glucose (carbohydrate) is perhaps the most primitive reaction and the most effective way for fixing carbon from atmosphere. This reaction converts CO_2 to glucose in presence of sun light by chlorophyl. Water is an obvious other required element. In India, we have extremely good amount of sunshine, enough water and plants have necessary chlorophyl thus, the limiting factor for this reaction can be CO_2! This is the main reaction of Carbon cycle that fixes carbon in soil via plants. There are many reactions that releases this fixed Carbon as CO_2 to atmosphere. This would emphasis the importance of this reaction – photosynthesis in carbon cycle as the only reaction acting as "carbon sink". Plants are known to produce CO_2 in absence of sunlight during night by using oxidative pathway of metabolism, hence CO_2 content of the farm in very early morning is quite high. Since CO_2 is heavier than other gases, it will stay in bottom i.e., near soil surface. This CO_2 will be utilized for photosynthesis in early morning and oxygen is generated, soon after if there is minimal activity in soil, CO_2 will be limited for photosynthesis. Hence, we

will have to bridge this gap and release CO_2 judiciously in afternoon till couple of hours before sunset. We will have to find out suitable mechanism for such controlled release depending on plant growth and sunshine.

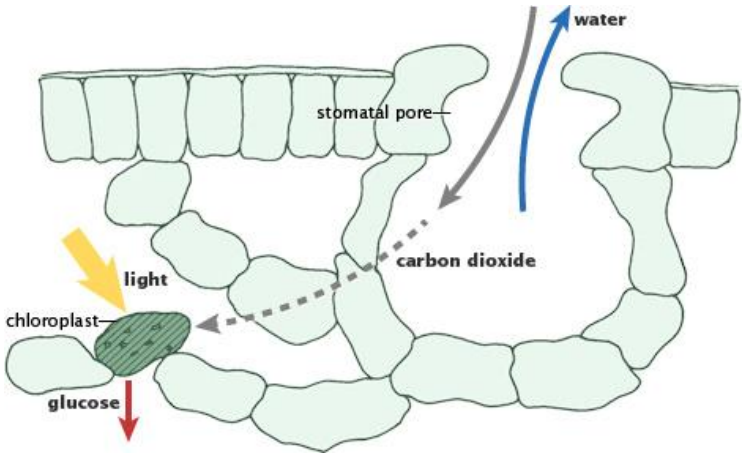

Fig. 5. Photosynthesis simplified illustration adapted from P.J. Sellers et al., 1992.

Opportunity for Sugar Industry Complex (Distilleries).
During fermentation, significant amount of CO_2 is liberated in the atmosphere. We need more ethanol for blending it as fuel, more ethanol, more carbon will be liberated and to control this environmental hazard to curb global warming it is essential to reduce this emission by reusing / recycling it. Many distilleries are installing CO_2 capturing plant. However, there is limited use of such CO_2 in chemical or food industry and increasing demand for ethanol will produce more CO_2 to atmosphere if unutilized. Can we put this CO_2 to its best use – for photosynthesis? This will fix carbon in soil via plants and can enhance soil carbon to support food chain of soil to revert the ecosystem back to glory.

Conclusion
Sugarcane industry is considered as carbon neutral industry as amount of CO_2 generated is almost equivalent to that captured by the sugarcane. However, if we can reduce the CO_2 emission by way of using it for plant growth including sugarcane, we will have double benefit – making our industry carbon negative and increasing farm yield to support farmer and society. This technology along with sugar processing without using lime will reduce carbon footprint dramatically and help our country to achieve carbon balance earlier than promised.
Let us make a beginning to double farmers income and improve soil fertility.

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VMK, AY and SM conceived the concept, wrote and approved the manuscript.

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