Chapter 5
Microbiological Carbon Sequestration:
A Novel Solution for Atmospheric Carbon – Carbon Sequestration through Biological Approach

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ABSTRACT

Global modernization demands a huge energy for developing new technologies to meet the increasing human needs. The initial source of energy was fossil fuels that might release some harmful gases. Burning of fossil fuels was practiced since the 18th century, which consequently resulted in 40% increase in atmospheric CO_2 according researcher. Presently, the atmospheric level of C is increasing day by day. However, this level would reach ~1000 ppm at the end of this century. The consistent discharge of CO_2 into the atmosphere is a major threat to global warming; hence, it is important to minimize the atmospheric CO_2 by using innovative carbon sequestration technologies. Therefore, soil and water can act as a sink for C storage with the assistance of microorganisms. Here, an attempt is made to discuss these processes in details, interactions between plant and microbes, and the requirement of C sources for C sequestration in the context of climate change. We also conferred about the development of microbial inoculants for C sequestrations and their application for sustainability of agro-ecosystems.

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INTRODUCTION

Carbon sequestration is a process of capturing and assimilation of C from CO_2 or other C associated gases as well as their transformation into organic and inorganic materials. In another word, C sequestration can be defined as;

1. "The process of removing C from the atmosphere to be deposited in a reservoir;"
2. "Capturing and storage of C where CO_2 is removed from fuel gases (such as on power stations) before it is stored in underground reservoirs" (UNFCCC, 2007), or
3. Long-term storage of CO_2 or other forms of C in reservoirs to either mitigate or diminish the global warming and avoid the risk of climate change.

Furthermore, C sequestration has been proposed as a strategy to enhance terrestrial status (soil, sediments, and vegetation), geological, and marine accumulation of the atmospheric greenhouse gases. These gases are mostly generated by anthropogenic activities particularly by burning fossil fuels either in natural or deliberate processes. Various biological, chemical or physical processes contribute to building up the global 'C-cycle', in which CO_2 is naturally captured and secured and its equilibrium is maintained in the atmosphere to sustain life. Similarly, some anthropogenic sequestration techniques (intentional geological or ocean storage) exploit these natural processes to capture CO_2 from its source of emission, and then stored in the ocean or underground channels such as old oil reservoirs, aquifers, and coal seams (Akinola, 2014).

Global industrial revolution is responsible for generating a huge amount of C emitted into the atmosphere. Also, rapid growth of anthropogenic activities is increasing the atmospheric level of CO_2 rapidly. Moreover, studies have shown that C emission is strongly combined with world economy and country development (Canadell et al., 2007). When comparing the growth rate of CO_2 emission from fossil fuel consumption during the period 1990 to 2006 it was found thatthe rate was increased from 1.3 to 3.3% $y^{-1,}$ (Canadell et al., 2007). In another study, there was a significant increase of C emission (about 29%) between 2000 and 2008 from fossil fuel consumption by emerging economies while C emission from land-use changes remained constant without any change (Canadell et al., 2007; Le Quéré et al., 2009). According to Mona Loa Observatory (USA), the average of CO_2 emission rate was observed from 2005 to 2014 and it was about 2.1 ppm y^{-1}. While the emission rate was almost two times the observed rate in1960, the overall average of annual increasing of concentration in 2014 was 3.98.55 ppm (http://co2now.org/, 2015). European Commission and Netherland Environmental Assessment Agency (EU-NEAA) collected the data of CO_2 emission from worldwide locations. The agency has reported that China, America, European Union, India, and Russia are the major countries that emit a significant amount of CO_2; however, Australia, America, Saudi Arabia, Canada and South Korea released the highest amount of CO_2 per capita (http://edgar.jrc.ec.europa.eu/news, 2014).

Since then, the global emissions of C that resulted from burning fossil fuels, land-use change, and depleting soil organic C into atmospheric C was approximately 270±30 Pg, 136±55 Pg, and 78±12 Pg (Pg = petagram = 10^{15} g = 1 billion ton), respectively (Lal, 2004). Another estimation has shown a significant increase of CO_2 emission from anthropogenic activities that increased from 6.3 Gt C to 8.7 Gt C during 1994 and 2009 respectively (Boden & Marland, 2014), which represents about 39% increase over that period (Sommer and Bossio 2014). Moreover, land-use changes such as burning forest, deforestation, soil degradation, and soil organic C (SOC) depletion, released annually additional 2