Arid ecosystem: future option for carbon sinks using microbial community intelligence

Leena Agarwal, Asifa Qureshi, Vipin Chandra Kalia, Atya Kapley, Hemant J. Purohit and R. N. Singh*

Desert, comprising one-third of the Earth's surface, was a synonym for 'no life' as it supports very less or no life due to nutritional stress and extreme weather. Microbial autotrophic biochemistry is the principal source of carbon in arid environment, but understanding of these processes in arid ecosystem is limited. Emerging molecular tools have identified associations of phototrophic and chemolithoautotrophic communities often termed as 'biological soil crust' or 'microbiotic crust'. They are the sole sources of carbon and nitrogen, collectively providing soil stability to support vegetation. Here the curiosity arises, whether this phenomenon could be exploited in deserts for carbon sink using microbial community intelligence. By following the precipitation event under regulated nutrient supply that promotes the soil microbial intelligence for autotrophy would enrich soil carbon and nitrogen which in turn support plant growth in desert. Additionally, bioaugmentation of rhizobacteria could enhance the process. This will enable us to refine and formulate our strategies to exploit CO_2-fixing microorganisms in such niches vis-à-vis supporting the carbon sink using microbial community intelligence.

Keywords: Arid ecosystem, biological soil crust, carbon sequestration, metagenome, microbial intelligence,

CLIMATE change is a global phenomenon shown to be related with the increase of CO_2 levels, which have been reported up to 399 ppm in May 2013 (Mauna Loa Observatoy, Hawaii). It is attracting the attention of the scientific community and correlations have shown that the increasing levels of CO_2 are directly associated with climate change effects[1]. There is a need to identify CO_2 sink options that could address the issue of ever increasing atmosphere CO_2 at global level. Is there an answer for this issue by increasing carbon sequestration capacity through degraded land or deserts? Deserts are a major portion of the terrestrial ecosystem, mostly considered as barren or without life due to extreme environment with unbalanced or compromised nutritional status[2]. Soils after a precipitation event, show subsurface soil heterotrophic activity. Deserts are oligotrophic in nature, here microbial autotrophy drives CO_2 fixation and significantly contributes to associated biomass at comparatively low levels than plants. Microbial CO_2 assimilation involves phototrophs and chemolithoautotrophs, viz. iron oxidizing, sulfur oxidizing, ammonia oxidizing and nitrifying bacteria. They are the key source of soil carbon in case of arid soil, principally sequestering CO_2 by Calvin–Benson–Bassham (CBB) cycle. Beyond the CBB cycle, there are five other options, viz. reductive acetyl CoA pathway (rACoA), reductive tricarboxylic acid (rTCA) cycle, 3-hydroxypropionate bicycle (3-HP), hydroxypropionate/hydroxybutyrate cycle and dicarboxylate-hydroxybutyrate cycle[3] available for the microbial community to assimilate CO_2.

Leena Agarwal, Asifa Qureshi, Atya Kapley and Hemant J. Purohit are in the Environmental Genomics Division, CSIR-National Environmental Engineering Research Institute, Nehru Marg, Nagpur 440 020, India; Vipin Chandra Kalia is in Microbial Biotechnology and Genomics Division, CSIR-Institute of Genomics and Integrative Biology, Delhi University Campus, Mall Road, Delhi 110 007, India; R. N. Singh is in the CSIR-National Geophysical Research Institute, Hyderabad 500 007, India.

*For correspondence. (e-mail: hj_purohit@neeri.res.in)

Arid ecosystem: a future option for carbon sinks

Increasing the capacity of desert and degraded land could be the next option to sequester carbon. Long-term storage of carbon in basic resources of an ecosystem is called carbon sequestration. The two major natural C sink options are ocean and terrestrial ecosystem, of which oceans can bring maximum carbon sinks since they make 71% of the Earth's surface. Terrestrial storage includes abstraction of CO_2 in both forest area as well as non-forest area like desert.

Forest

Forest ecosystem is a reservoir for more than 70% of the terrestrial and soil organic carbon[4,5]. Although forest