Spotlight on using constructed ecosystem for understanding the impacts of climate change at the mesocosm level

Wenfa Ng

Citizen scientist, Singapore, Email: ngwenfa771@hotmail.com

Abstract

Climate change is a phrase that has entered the popular lexicon. But, beyond temperature and sea level rise, much of the world's population remains ignorant of the other effects of unabated climate change. One such impact is the effect of climate change on the world's food supply. Specifically, temperature rise may affect crops resilience and yield. This, in combination with many of the world's grain production regions situated close to the coast meant that sea level rise and saltwater intrusion may have a significant negative effect on the resilience of the world's food supply system. Hence, researchers have set forth on the quest to understand the effect of climate change on vegetation growth using constructed wetlands. Such lab-based constructed wetlands enable the simulation of temperature rise and changes in water salinity thought to be mediated by anticipated climate change. One research thrust in this endeavor is in understanding how temperature rise would affect the types and relative abundance of important nitrogen-fixing bacteria that nourishes the root microenvironment in promoting plant health. As an extension to the concept, the possible use of bioaugmentation in resupplying nitrogen-fixing bacteria to soil that is depleted in this class of microbes has also been studied. But, a more far-reaching implication of the work lies in expanding the system to understand how a combination of temperature and sea level rise would affect mangrove regions around coastal areas in the world. Specifically, mangrove regions help serve as a sponge during periods of excessive rain, storms or high tide; thereby, offering coastal protection. However, health of mangrove is deeply connected to salinity of water and temperature rise, and together with the ecosystem that it supports, holds important implications on how coastal wetlands would likely play a frontline role in ameliorating the effects of unbated climate change in this century and beyond. Overall, constructed wetlands in lab offer a controlled experimental platform for systematic understanding of the effects of climate change on vegetation. But, its larger incarnation in the real-world, for example, in mangrove regions around coastal cities in the world, would provide a reality check on how resilient our extant wetlands are to the effects of climate change. Judging by the erosion of many wetlands around the world due to a combination of sea level rise and temperature increase, the future looks bleak.

Keywords: constructed wetland, climate change, temperature rise, sea level rise, coastal regions, microbial diversity, nitrogen-fixing bacteria, bioaugmentation,

Subject areas: ecology, environmental engineering, climate change,

A report in *New York Times*, Link, describes the use of constructed ecosystem such as a wetland for understanding the impact of climate change on vegetation growth, especially near the coast. Specifically, increasing atmospheric carbon dioxide concentration has manifested as more rapid climate change, which has changed growing patterns of vegetation worldwide. Hence, given the importance of vegetation growth to maintaining food security around the world, especially in impoverish regions, it is critical to understand the effect of climate change on vegetation growth, particularly near coastal regions, where many of the world's agricultural rice and wheat baskets sits near the equator and sub-tropical regions, respectively.

Using constructed wetlands as a model system, researchers has ventured into understanding how climate change has influenced vegetation growth and, in turn, how changes in vegetation type and growth rates, have helped ameliorate the effect of rising sea levels on coastal erosion rates. Specifically, constructed wetlands serve as engineered systems for conducting tailored experiments designed to understand the specific effects of different climate change parameters (e.g., temperature rise, humidity decrease, change in rainfall patterns and intensity, and carbon dioxide concentration in the atmosphere) on the growth rates of various plants. Such data would help fill an important gap in our understanding of how plant growth would be influenced by a combination of temperature rise, sea level rise and salt water intrusion that accompany climate change.

By understanding how plant growth could be affected by climate change parameters, especially temperature rise, and elevated carbon dioxide concentration in the atmosphere, careful selection of plant species may provide a buffer against sudden rapid onset of dangerous climate change, which could possibly throw the world's climate system into disequilibrium, thereby, leading to significant disturbance in the world's food supply.

Plant growth, especially in oligotrophic (or nutrient poor) soil, requires the help of many species of microorganisms, an important species of which is nitrogen fixing bacteria. Hence, constructed wetland systems allow scientists to critically assess, through a range of culture and molecular profiling techniques, the types and relative abundances of different species of microbes present in and around various surfaces of plants (such as the roots, stem and leaves) under different climatic conditions available, at present, around the world. By understanding the effect of climate change on microbial diversity, in proximity to the plant species under study, mankind has a window into how microbes influence crop productivities in water-logged soils necessary for cultivating rice crops that feed a substantial fraction of the world's population. Doing so would afford us an enabling tool of tuning the microbial community surrounding a crop growing region for enhancing the food crop resilience against the damaging effects of climate change on plant growth such as the effect of high temperature on plant growth rate. For example, one approach is bioaugmentation. In this case, nitrogen-fixing bacteria, not harmful to overall ecosystem stability and health, could be augmented into soil where the food crop is grown, and help improve the nitrogen mix of the soil necessary to propel plant growth. But importantly, field data must demonstrate the safety of the bioaugmentation approach in improving plant growth without contributing to instability of the ecosystem.

Finally, depending on the size of the constructed wetland, the system could be used as a model for understanding the effect of climate change on plant growth and microbial diversity at different scales, each necessary for correlating the impact of scale on ecosystem dynamics and interaction between microbes and plant as they both learn and adapt to ensuing climate change of different magnitude and severity.

Hence, putting climate change into the equation for understanding how plant growth and productivities is likely to be impacted in the future points to the need for engineered systems for conducting controlled experiments, where the data could potentially lend a lens into the effect of climate change on plant growth and microbial diversity. Constructed wetlands near coastal regions of the world, whether in temperate sub-tropical climes or in the tropics, provide a useful system amenable to controlled experimentation for detailing how gradual temperature rise could impinge on vegetation growth as well as influence the type and relative abundances of different microbial species, some of which important for plant growth and health. Such experimentation, depending on the size of the constructed wetland, could also offer useful insights on how differing scales afford specific systems greater resilience against climate change impacts. Usually in the medium size range, scaling effect of ecosystem size influence plant and microbial communities' robustness against temperature rise, and increasing carbon dioxide concentration in the atmosphere points to an increasing intrinsic trade-off between scale of system and impact of climate change, a point seldom noted in studies seeking to understand the effect of climate change on ecosystem.

Conflicts of interest

The author declares no conflicts of interest.

Funding

No funding was used in this work.