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EDITED AND REVIEWED BY
Yuncong Li,
University of Florida, United States

*CORRESPONDENCE
Ali Mahbub Quoreshi,
aquoreshi@kisr.edu.kw

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Editorial: Soils and vegetation in desert and arid regions: Soil system processes, biodiversity and ecosystem functioning, and restoration

Ali Mahbub Quoreshi [1]*, Vinod Kumar [1], Rasheed Adeleke [2], Laiye Qu [3] and Alain R. Atangana [4]

[1]Kuwait Institute for Scientific Research, Kuwait City, Kuwait, [2]North-West University, Potchefstroom, South Africa, [3]Chinese Academy of Sciences (CAS), Beijing, China, [4]World Agroforestry Centre, Abidjan, Côte d'Ivoire

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Editorial on the Research Topic
Soils and vegetation in desert and arid regions: Soil system processes, biodiversity and ecosystem functioning, and restoration

A fundamental characteristic of desert ecosystems is continuous adaptations to arid environments and other related stresses, from the organismal level to the landscape scale. However, Desert ecosystems are home to unique flora and fauna that are adapted to extreme arid climatic conditions. Although such ecosystems are resilient in nature, changing climate, rising temperature and CO_2, low rainfall, poses great stress on the ecosystem structure and function. The species are subjected to vulnerability and extinction due to various anthropogenic factors. Furthermore, the soils of arid regions are generally sandy with extremely low organic matter, having very low nutrients and microbial activity. The ultimate challenge for conservation of the desert ecosystem is meeting the current demand, especially with the increasing human population and requirement for land and food security. Arid regions are resource-limited regions and are considered one of the most difficult environments to survive and succeed on this planet, incorporating huge challenges to maintain vegetation development and productivity. An outstanding question is to what extent does soil biodiversity play an integral role as a determinant of plant diversity and productivity, and how does this influence ecosystem function? Resolving these challenges, we seek to address this gap and for further understanding of how improved knowledge of plant-soil biological processes in arid regions supports our capacity to understand the ecological processes for successful restoration and revegetation of arid ecosystem.

In this research topic issue, we have gathered contributions from scientists working in diverse disciplines who have common interests in fundamental and applied research on the desert and arid lands, the effect of desertification on soil and microbiomes, soil system processes, plant and soil biodiversity, restoration, and revegetation of degraded arid lands. The key emphasis was also given to Research Topics related to microbial inoculum applications, and soil amendments for the recuperation of soil health. The goal was to gather content related to the above-specified topics under one cover to achieve a better understanding of ecosystem functioning and to contribute to Conservation and restoration ecology by discovering newer insight into the contributing factors that disturb the balance of ecosystem functioning. We have received 10 manuscripts from authors across the globe with expertise in arid-land ecosystem and restoration biology. In total, 6 original Research papers have been accepted and included in the special issue.

Qu et al. investigates how soil microbiomes and enzymatic activities respond to differences in a particular local climatic condition both in the presence or absence of shrubs as cover canopy. The responses determined were centered around dominant shrub species, *Artemisia gmelinii*, in a semi-arid area of southwestern China, while variation in the amount of local rainfall was observed across four selected study sites. The findings reveal that covered soil exhibits increased abondance of arbuscular mycorrhiza fungi while that of bacteria remained unaffected under similar conditions. Differences in the abondance between soil samples occurred only at sites of low rainfall. Actives of hydrolytic enzymes were also positively influenced under covered conditions and at higher rainfall, though the overall enzyme activities could not be differentiated. This suggests pronounced influence of variation in rainfall over the enzyme activities rather than shrub canopy. In general, vegetation distribution plays important role in the abondance of soil microbial communities which in turn enhance enzyme activities, promote organic nutrients, and improve physicochemical properties of the soil. These factors could as well be varied with varying climatic conditions. The study thus, emphasize on the dependence of vegetation and climate on local environment in regulating biological activities in the soil.

Water availability is a major limiting factor that affects the vegetation in the desert ecosystem. The native plants exhibit important adaptations to use water efficiently for maintaining optimum vegetation. Madouh studied the eco-physiological responses of native desert plant species to drought and nutritional levels in Kuwait. In the study, the author quantified the biomass production and nutritive values of three native desert grass species under the influence of drought stress. The observed response of the grasses differed from drought stress through changes in stomatal conductance. The metabolic changes were contributing to Under natural desert conditions. These adjustments may reduce transpiration demand relative to water deprivation, leading to improved species establishment and supported adaptation to severe desert environments. The outcome of the study helps us understand the physiological responses and the water requirements of desert plant species especially for the restoration of ecological functions and biodiversity conservation.

The biodiversity and ecosystem multifunctionality play a key role in the processes of ecological restoration. Wang et al. original research work focuses on plant functional and phylogenetic diversity that regulate ecosystem multifunctionality in semi-arid grassland during succession. A number of diversity indices and eight function variables were measured, and the results suggest that functional and phylogenetic diversity are more important than taxonomic diversity in predicting ecosystem multifunctionality, and that multidimensional biodiversity indices should be jointly considered to better predict ecosystem multifunctionality during the succession of semiarid grasslands.

Anthropogenic activities such as mining have tremendous negative impact on the ecosystem and pose a high degree of stress for restoration. It is important to determine the potential of the association of microbial and/or manure amendments for the effective rehabilitation of the environment post mining. Yonli et al. in their original article demonstrated the response to microbial and manure amendments during the rehabilitation of waste rock dumps in the Essakane gold mining site, Burkina Faso by planting *Senegalia Senegal.*

The seedlings of *S. Senegal* was inoculated with arbuscular mycorrhizal (AM) fungi and *Mesorhizobium plurifarium*. It was interesting to note that, manure-enriched substrates had decreased nodulation and AM colonization in nursery conditions, but significantly enhanced plant height and dry mass when compared to unamended substrate. Authors have noted that the plant growth and survival rate were reduced in the field conditions under high-rate manure amendments. This was attributed to less AM colonization and root nodulation. Plants highly colonized by AM survived better after out-planting on un-altered and moderately amended substrates. The findings herein further confirm that microbial inoculation and manure-enriched substrates generate positive plant responses for vegetative restoration in post-mining environments although manure enrichment in forest nurseries should be cautiously applied given that high rates may impede establishment of plant symbioses, thereby affecting their performance on waste rock dumps following out-planting.

Mine exploration sites undergo several changes which result in negative environmental implications such as reduction in vegetation cover, soil erosion, soil contamination and alteration of soil physiochemical and biological properties. The main purpose of disturbed mine site reclamation is to return it to a state similar to what it was before mining. Plants that have been environmentally adapted to mining sites can be used to re-establish vegetative cover such those utilized in

the study by Yonli et al. who evaluated the rehabilitation potential of *Vachellia tortilis* (Umbrella thorn) tree species in sub Sahelian mining areas at Essakane, northern Burkino Faso. Although alteration of soil physiochemical may have adverse impact on the establishment of plant communities, soil biological activities such as effective microbial association and soil-plant-microbes' interactions are also extremely important in the successful establishment of vegetation communities. The study reveal that umbrella thorn can endure and flourish in heavy metal-rich mine wastes, particularly arsenic-rich mine wastes, demonstrating its appropriateness for regeneration of such disturbed areas. The results also show that there is a strong correlation between the umbrella thorn growth and root colonization by microsymbionts indicating negative effect of soil characteristics on the establishment of microbial colonization with roots.

Liu et al. elucidated the influence of land reclamation on wind erosion by examining soil texture and soil nutrients in the Mu Us sandy land. Wind erosion is a source of concern in arid and semi-arid environments because of its detrimental effects on soil texture and nutrient availability, which could lead to land degradation and desertification. Recently, land reclamation activities have been increased considerably in the Mu Us Sandy Land (MUSL) area to complement cultivated lands (CLs) occupied by urbanization. Except for changes in total nitrogen content, which were mostly impacted by nitrogenous fertilizer use, the findings in this study show a considerable decrease in soil particles and soil nutrients in cultivated land as a function of the number of years of cultivation. The analysis results indicated that in the MUSL, the diameter of erodible particles susceptible to wind erosion ranged from 60 to 400 μm. Authors concluded that the new CLs can easily be degraded and impacted by wind erosion.

The leading characteristics of degradation of arid region ecosystems include a reduction in vegetation productivity, loss of species diversity, diminishing soil functions and increase in soil erosion, sand movements, loss of water, and reduction of soil organic matter. The interactions of plants, soil, and microorganisms within the rhizosphere profoundly impact the biogeochemical cycling and soil system processes. To achieve a resilient and self-sustaining ecosystem, it is crucial to consider reinforcing the recovery processes of degraded ecosystem by restoring the components and soil ecological processes including soil microbial communities of a disturbed site or ecosystem to bring the restored sites back to a normal state and assist in the resumption of normal ecological functions.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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