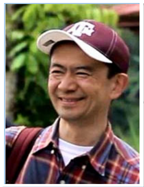
【Grant-in-Aid for Scientific Research (S)】

Optimal soil environment based on the structural evolution of soil, the largest carbon store on the earth's land



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Project Information	Project Number : 24H00057 Keywords : Soil pore, soil organic matter, carbon sequestration, global warming, climate change	Project Period (FY) : 2024-2028

Purpose and Background of the Research

●Outline of the Research

Soil is the largest terrestrial carbon reservoir, thus conservation of organic soil is essential for ecosystem stability. However, soils are being degraded by global warming and climate change. The applicants found that the development of very simple structures such as aggregates and tubular pore facilitates soil water retention, downward infiltration, and increased organic matter. These may be among the processes of soil development as plants move onto land. They are strongly influenced by gravity in relation to inertial forces, and enabled water retention to withstand drought. Transitions were also observed in the microbial community with slight changes in the physical environment, indicating that the soil environment created by the structure had a significant impact also on microorganisms. The objective of this study is to elucidate the optimal soil environment that can withstand climate change by increasing water use efficiency from the development of soil pore structure and mitigate global warming through carbon fixation from organic matter conversion.

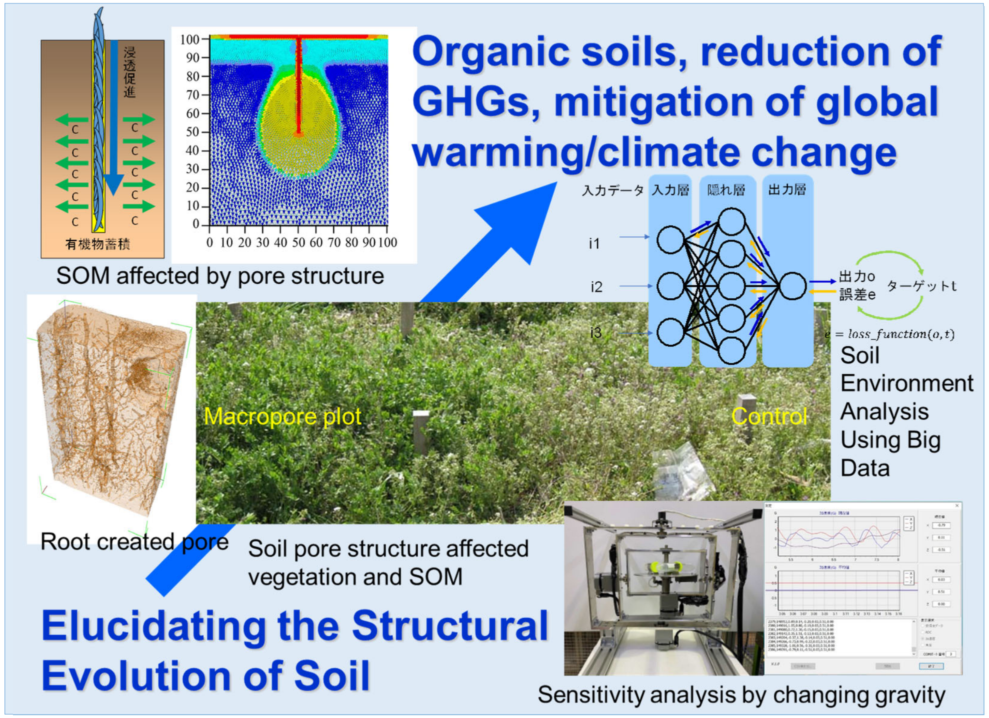

Figure 1. The outline of the research SOM: Soil organic matter

●Background of this study

Artificial macropore technique, one of the applicant's core environmental technologies, promotes downward infiltration in environments with poor permeability to increase soil organic matter and reduce topsoil runoff. This has been developed through the NEXT Program (2011-2013), Foundation B (2014-2016), Foundation A (2017-2020), and Foundation A (2021-2023). Since there should be a breakthrough point where downward infiltration becomes dominant with the terrestrial expansion of lichens and vascular plants, we mainly considered referring to the conditions for the formation of organic soils from the perspective of soil structure.

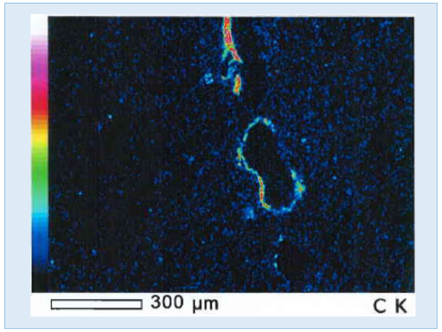

Figure 2. Carbon accumulation around macropores (SEM photo) Organic matter is clearly transported to deeper profile by water infiltration

Expected Research Achievements

●Novelty of this research and outcomes

We will focus on the early process of soil structure development, to follow the process of terrestrial soils becoming organic in terms of soil structure such as aggregates and tubular pore. Furthermore, we will conduct big data analysis on terrestrial areas to clarify the cause-and-effect relationship. The goal is to find fundamental measures to restore soils degraded by climate change, global warming, and especially human activities. Applicants have examined the soil pore structure closely and developed the artificial macropore. When this artificial macropores was applied to degraded soils, vegetation recovery and soil organic matter conversion were achieved. In addition, a change in the microbial community was observed with slight changes in the soil physical environment, and gradually proteobacteria involved in carbon and nitrogen fixation were observed. In other words, we could state that the development of soil pore structure and downward transport of water and materials play a decisive role in microorganisms, vegetation, and the organic environment. If we can clarify the processes that made the soil organic now, we can fundamentally rethink the current seemingly fragile soil environment. This will provide guidance for terrestrial carbon conservation and mitigation of climate change, which is a very big gospel. Adding structural and dynamic aspects to the current biochemistry-based exploration of the soil environment would be a highly creative study.

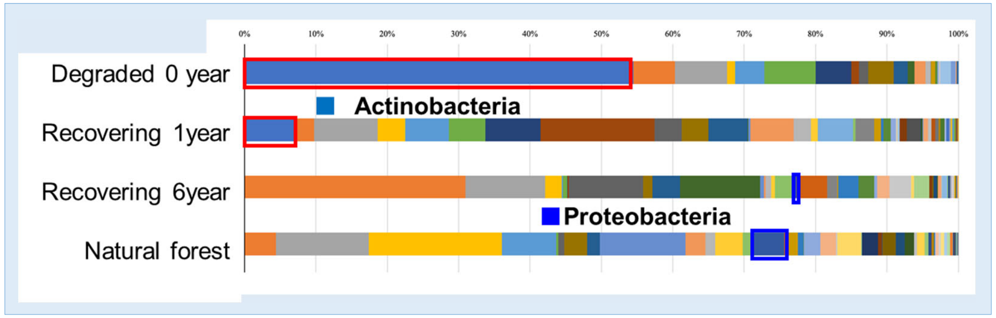

Figure 3. Microbial community changes during recovery from degraded soil (0Y) to natural forest (F).

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