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Research Progress on The Influence of Gully Treatment on Soil-plant Ecological Stoichiometric Characteristics in Loess Hilly Region

Jianglong Shen[1, 2, 3, 4, 5, *], Ziru Niu[1, 2, 3, 4, 5]

[1]Shaanxi Provincial Land Engineering Construction Group Co.,Ltd., Xi'an 710075, China
[2]Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, Xi'an 710021, China
[3]Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co.,Ltd., Xi'an 710021, China
[4]Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an 710075, China
[5]Land Engineering Technology Innovation Center, Ministry of Natural Resources Xi'an 710075, China
[*] Corresponding author

Abstract: Ecological stoichiometry is the integration of the basic principles of biology, chemistry and physics, and the study of the quantitative relationship of chemical elements in the ecological process. It organically combines the theories of various studies in ecology, provides a method to study the econometric relations and laws in the chemical cycle and process of elements, and mainly emphasizes the stoichiometric characteristics of elements. By sorting out the existing research, we can provide a direction for the follow-up research.

1. Introduction

Yan 'an gully land reclamation is a new gully land reclamation mode aiming at the special geomorphology in the hilly and gully region of the Loess Plateau, which uses modern engineering means to quickly cover gully land and build comprehensive construction of fields, DAMS, canals, roads and forests, and is the integration and innovation of land reclamation projects and water and soil conservation backbone projects. While effectively reducing flow and sediment and conserving soil and water, gully treatment and land reclamation plays an important role in changing soil nutrients and promoting soil nutrient cycling. It has been widely applied in gully areas of the Loess Plateau, and studies have shown that gully treatment and land reclamation also have a certain impact on soil organic matter and soil corrosion resistance. It plays an important role in realizing efficient utilization of soil and water resources in loess gully and ecological governance of small watershed, and is a systematic project to improve farmland, protect ecology and benefit people's livelihood.

2. Ecological Stoichiometric Concepts

Stoichiometry, a branch of science first described by Richter in 1972, deals with the qualitative aspects of material changes and chemical characteristics. It emphasizes the relationship between chemical composition and structure of substances. For example, calculations such as mass and percentage of chemical reactions. Sterner and Elser(2002) pointed out that, from the stoichiometric perspective, an organism is just like a whole and dynamic macromolecule, which carries out chemical recombination all the time within and between different molecules. In this case, every organism can be reduced briefly to a stoichiometric composition. The ecological environment is also composed of chemical substances, so the interaction between various components must involve the reorganization of chemical elements. Therefore, there is also a stoichiometric law in ecology, and the transfer and reorganization of chemical elements in the interaction process between organisms in nature also follows the law of conservation of mass. Thus, in order to view nature as a unified part, the term "ecological stoichiometry" is introduced, which can also be called "stoichiometry". Ecology chemometrics integrates biology, physics and chemistry, including the basic principles of ecology and stoichiometry, as well as the principles of biological evolution (Michaels 2003). It is a study of the influence of the constant relationship between elements on the relationship between components of a system. It is also the study of the constant relationship of energy between the components of an ecosystem and the mutual balance between different chemical elements (mainly C, N, P). Ecology chemometrics acts as a medium through which research at different levels in nature can be unified.

At present, there are two important theories in chemometrics in Ecology: dynamic equilibrium theory and growth rate theory. In the process of continuous evolution, the nutrient element composition of normal organisms is basically stable, forming a relatively stable homeostasis mechanism, that is, organisms maintain their own chemical composition in response to changes in the external environment. The ability to maintain a relatively stable range. Even though the environment is constantly changing, the composition of the organism will remain the same.

The phenomenon of maintaining stability within a given range and not being very different from environmental conditions is called "dynamic equilibrium". From the perspective of ecological stoichiometry, the element composition ratio of organisms is maintained within a specific range and is dynamic and stable, and the change of any element will have a certain impact on the original ratio, resulting in the change of the original ratio. In the process of evolution, an organism will inevitably be affected by different degrees of external environment. For example, changes in biological, climatic and geological conditions will have different degrees of influence on it, and the ratio of elements of an organism will change in different degrees due to these factors. Therefore, The theory of Ecology chemometrics can

correlate the change of organic element ratio with the evolution of organisms, and determine the evolution of organisms by the change of organic element ratio. In addition, during the growth process of organisms, when they constantly exchange material information with the external environment, they will consume and discharge elements with different ratios to the original elements in the environment, thus causing the change of the ratio of elements in the external environment of organisms. Thus, there is a profound feedback mechanism between the ratio of elements in an organism and the ratio of elements in its environment. The two interact with each other, and if their stoichiometric ratios are out of harmony, they may affect the behavior of populations.

3. Advances in Ecological Stoichiometry at Home and Abroad

In 1958, A.Redfield of Harvard University investigated the content of carbon, nitrogen and phosphorus in Marine animals, plants and microorganisms, and found for the first time that there was a certain ratio of carbon, nitrogen and phosphorus in aquatic animals and microorganisms, that is, the mol ratio was a specific value, which was later called Redfield ratio. He points out that the rate is not set in stone, but is influenced by the interaction between the organisms in the community and environmental conditions. This discovery was of great significance and paved the way for the development of the subject thereafter. Reiners (1968) made a breakthrough in associating stoichiometry with research in ecology on the basis of others' theories, and he also discovered ecological models based on the basis of stoichiometry. Elser proposed in 1988 that, since the difference in the composition of organisms or biological partial entities (e.g., molecules, organelles, cells, and organisms) is related to their related functions, the key point of the application of stoichiometric theory in ecology is to realize that an organism or biological partial entity (e.g. Molecules, organelles, cells, organisms, etc.) to distinguish them clearly. In 2004, Eeology journal set up the section of ecological stoichiometry, which is dedicated to reporting the research progress and scientific achievements of ecological stoichiometry, such as the relationship between growth rate and RNA concentration, and the relationship between C, N and P content, etc. The development of ecological stoichiometry was mainly focused on aquatic ecosystems at the beginning. Comparatively speaking, the research of ecological stoichiometry on terrestrial ecosystems started later than that of aquatic ecosystems, but it has made great progress in the past decade. Reich and Oleksyn(2004) analyzed 5,087 observed data of 1,280 species of plants from 452 sites around the world, and explored the distribution pattern of N and P content in plant leaves and the following values: The correlation between P ratio and variability on a large scale of geographic location, climate temperature, or other geographic environmental factors. The research results showed that with the decrease of latitude and the increase of annual mean temperature, the contents of N and P in plant leaves tended to decrease gradually, while the N: P ratio tended to increase gradually. Therefore, they proposed the temperature-plant physiology hypothesis, temperature-biogeochemical hypothesis and soil substrate age hypothesis. Although our study in ecological stoichiometry started late, but because of our country's vast territory, vast territory, rich biological resources, climate and geographical environment complex and diverse, in the study of ecological stoichiometry has the advantaged advantage, is the ideal state for the study of ecological stoichiometry, so the domestic study in this aspect of the late start, but rapid development. At present, most domestic researches on ecological stoichiometry focus on plant leaves, which not only involve different community types and different succession stages, but also include different artificial intervention methods. Among them, researches on stoichiometric characteristics of N, P and N: P ratio in plant leaves are the most extensive. However, at present, there are few studies on coupling comparison between above-ground and subsurface parts of plants and ecological stoichiometric ratios in soil at different growth stages.

4. Ecological Stoichiometry of Soil

Soil, as an important part of terrestrial ecosystem, is an important place for material and energy exchange in terrestrial ecosystem. Soil is the material basis which has great influence and significance on the growth process of plants. As the most important source of plant growth and nutrient elements (C, N, P, K, etc.), soil nutrient content ratio changes and distribution rules will have a huge impact on the whole ecosystem. The changes of soil nutrient status directly affect the available nutrient content of plants, and vegetation restoration plays a positive role in improving the physical and chemical properties of soil. Lower soil nutrient availability usually results in changes in nitrogen and phosphorus content and photosynthetic capacity of plant leaves. Soil C: N: P ratio is the ratio of carbon to nitrogen and phosphorus in organic matter or other components. It is an important index of the composition and quality of soil organic matter, and the main index reflecting the carbon, nitrogen and phosphorus cycle in soil.

Ecological stoichiometry is a new direction in the field of soil chemistry and a new way to study the interaction of soil ecosystem and the cycling of carbon, nitrogen and phosphorus. Its application in the research of soil nutrient cycling and limiting effects has attracted a lot of attention. Wardle et al. (2004) found that in most long-term observational studies, as the age of soil substrate increases, the N: P ratio of fresh litter and humus will increase, so that similar forest degradation will occur in forest ecosystems from tropical to temperate zones, leading to a decrease in soil phosphorus availability. Some domestic experts and scholars on soil ecological stoichiometry (He Jinsheng et al. 2010; Wu Jianping, 2016; Zhang Haidong et al., 2016), studies on soil ecological stoichiometric characteristics of reclaimed vegetation woodland in the loess hilly region have been reported (Chen Yanan et al., 2014; Yang Jiajia et al. 2014), but mainly focused on differences in soil nutrient content or reserves and microbial biomass in different latitudes (Zhang Xiangru et al. 2013), different vegetation types (Zhu Qiulian et al. 2013), and comparison of soil microbial biomass in different vegetation types (Wu Jianping et al. 2013). Due to the influence of soil formation factors such as climate, landform, vegetation, age, soil animals and human activities on the total amount of soil carbon, nitrogen and phosphorus, the spatial variability of soil C: N: P ratio is large.

5. Ecological Stoichiometry of Plants

The content of phytochemical elements not only reflects the ability of plants to absorb and store mineral nutrients from soil under certain habitat conditions, but also reflects the

stoichiometric ratio characteristics of plants themselves in terrestrial ecosystems. The growth and development of plants are produced by photosynthesis of leaves, which are valuable organs for C-cycle and important nutrient storage in forest ecosystem. Roots are the main underground biomass, which is an important organ for plants to absorb water, carbon dioxide and inorganic salts from the soil. It is important to study the nutrient content and stoichiometric characteristics of leaves and roots for plant growth.

As essential mineral nutrients for plant growth and common limiting elements in ecosystem, carbon, nitrogen and phosphorus are functionally related in plants and have important interactions among them. There have been a lot of studies on the characteristics of plant ecological stoichiometry abroad, although the domestic research started late but developed rapidly. Ecological stoichiometry focuses on the relationship between the ratio of nitrogen and phosphorus in plants, because the relatively constant N: P ratio in terrestrial plant organs is an important adaptation mechanism for plant survival on Earth. Therefore, plant N: P ratio can be used as a breakthrough point to study the relationship between plant ecological stoichiometry, environmental change and ecosystem stability. C: N and C: P of plant leaves mean the ratio relationship between C(biomass) and nutrient, which can be simply understood as the productivity per unit nutrient, i.e Nutrient use efficiency. Grace's (1997) study on tropical plants showed that N: P was positively correlated with growth rate at low growth rate. At high growth rate, N: P is negatively correlated with growth rate. Domestic and foreign scholars have conducted extensive studies on the stoichiometric characteristics of plant leaves in different forest types, regions and succession stages (Agren and Weih 2012, Mcgroddy et al. 2004; Yan Enrong et al. 2008; Yu et al.2010). Among them, studies on the stoichiometric characteristics of N, P and N: P in plant leaves are the most extensive, including the seasonal changes of ecological stoichiometric characteristics of plant leaves, as well as the correlation of stoichiometric characteristics between plant leaves and different organs of fine roots. Han et al. (2005) studied leaf nitrogen and phosphorus of 753 terrestrial plants in China. Compared with the global P content, the P content of Chinese plants is relatively low, which may lead to higher leaf N: P than the global average level.

6. Discussion

Soil is a necessary environment for plant growth, and soil nutrients directly determine plant growth environment. The analysis of the balance of carbon, nitrogen and phosphorus elements in the newly built soil in the Loess Plateau is beneficial to the regulation of plant and soil nutrient composition, and promote the stability of the ecosystem. The analysis of soil ecological stoichiometric characteristics is of great significance for understanding and mastering the nutrient cycling process, feedback regulation mechanism and response mechanism to external disturbances in the ecosystem.

Gully treatment and land construction dramatically changed the topography and geomorphology of the small watershed in a short time, and significantly changed the hydrological and material cycling conditions of the watershed. Therefore, the study of the relationship between the physical and chemical properties of the soil in the new structure and the influence of vegetated soil interaction on the physical and chemical properties of the soil is helpful to provide references for the improvement of soil quality in the new cultivated land and the construction of high-standard farmland.

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