

南方丘陵红壤区森林土壤 C、N、P 生态化学计量特征及其影响因素

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摘要:【目的】生态化学计量学在了解土壤养分对植被的约束以及维持森林生态系统服务方面具有重要作用,为明确南方丘陵红壤区森林碳、氮、磷(C、N、P)生态化学计量学特征及其影响因素,明晰该区域森林土壤主导养分元素,为南方丘陵红壤区森林可持续经营和土壤改善管理提供理论依据。【方法】本研究采取随机布点、专题布点和林分布点相结合的方法,并依据 DEM 衍生的地形、水文信息和 DOM 提高的植被信息等高分辨率多源数据,共计布设 323 个样点,包括针叶林 31 个、常绿阔叶林 98 个和针阔混交林 134 个(分别记为 CF、BF 和 CBF)。并通过测定森林土壤中有有机碳(SOC)、全氮(TN)和全磷(TP)的含量,并提取对应点的典型生物多样性指标[归一化植被指数(NDVI)、氮反射指数(NRI)、叶面积指数(LAI)和叶光合有效反射分量(FPAR)],采用地质统计学、Person 相关性分析和回归分析等方法对森林土壤 C、N、P 生态化学计量特征及其影响因素进行评价和分析。【结果】结果表明:在 3 种典型林分类型中,均为在 BF 土壤 SOC、TN 和 TP 含量最高,具体为不同林分类型土壤 SOC 和 TN 含量变化表现为:BF>CF>CBF,而土壤 TP 含量则表现为:BF>CBF>CF;而 3 种典型林分类型中,均为在 CF 土壤 C:N、C:P 和 N:P 最高,且土壤 C:N、C:P 和 N:P 在针叶林中均属于中等变异,而在常绿阔叶林和针阔混交林中均属于强变异。土壤 SOC 和 TN 之间存在较强的关联性,且二者均主要受到海拔和土壤 pH 的影响,而土壤 TP 含量空间变异性较小。土壤 C、N、P 化学计量比主要是受到植被类型、坡位、海拔和土壤 pH 等环境因子的影响,且海拔因素呈正相关,而与土壤 pH 呈负相关。而在土壤养分因素中,土壤 SOC 含量是该地区土壤 C、N、P 化学计量比主要的影响因素。土壤 C、N、P 化学计量比与生物多样性指标之间并没有明显的关系。【结论】南方丘陵红壤区 3 种典型林分类型土壤中,常绿阔叶林土壤 SOC、TN 和 TP 含量较高,土壤养分相对丰富,但整体上研究区 TP 含量相对匮乏,森林植被主要受 P 元素的抑制。土壤 C、N、P 化学计量比受到海拔、土壤 pH、植被类型、坡位等的影响。该区域森林植被生长状况相对旺盛,生态系统相对健康。这些结果将有助于改善森林经营和森林土壤保护管理。

关键词: 林分类型; 土壤 C、N、P; 生态化学计量特征; 影响因素

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Ecological Stoichiometric Characteristics of Soil C, N, and P in Three Typical Forest Types in the Hilly Red Soil Region of Southern China and Influencing Factors

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Abstract: 【Objective】 Ecological stoichiometry plays an important role in understanding the constraints of soil nutrients on vegetation and maintaining forest ecosystem services. In order to clarify the ecological

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stoichiometric characteristics of forest carbon, nitrogen and phosphorus (C, N, P) and their influencing factors in the hilly red soil region of southern China, and to clarify the dominant nutrient elements of forest soil in this region, it provides a theoretical basis for sustainable forest management and soil improvement management in the hilly red soil region of southern China. **【Method】** In this study, a combination of random distribution, thematic distribution and forest distribution points was adopted, and based on high-resolution multi-source data such as terrain, hydrological information derived from DEM and vegetation information improved by DOM, a total of 323 sample points were set up, including 31 coniferous forests, 98 evergreen broad-leaved forests and 134 coniferous and broad-leaved mixed forests (recorded as CF, BF and CBF, respectively). By measuring the contents of organic carbon (SOC), total nitrogen (TN) and total phosphorus (TP) in forest soil, and extracting the typical biodiversity indexes [normalized difference vegetation index (NDVI), nitrogen reflection index (NRI), leaf area index (LAI) and leaf photosynthetically active reflectance component (FPAR)] of the corresponding points, the ecological stoichiometric characteristics of C, N and P in forest soil and their influencing factors were evaluated and analyzed by geostatistics, Person correlation analysis and regression analysis. **【Result】** The results showed that the contents of SOC, TN and TP in BF soil were the highest among the three typical forest types. The changes of SOC and TN contents in different forest types were as follows : BF > CF > CBF, while the soil TP content was as follows : BF > CBF > CF. Among the three typical forest types, the soil C : N, C : P and N : P in CF were the highest, and the soil C : N, C : P and N : P belonged to moderate variation in coniferous forests, and belonged to strong variation in evergreen broad-leaved forests and coniferous and broad-leaved mixed forests. There was a strong correlation between soil SOC and TN, and both of them were mainly affected by altitude and soil pH, while the spatial variability of soil TP content was small. The stoichiometric ratios of soil C, N and P were mainly affected by environmental factors such as vegetation type, slope position, altitude and soil pH, and the altitude factor was positively correlated, while negatively correlated with soil pH. Among the soil nutrient factors, soil SOC content is the main influencing factor of soil C, N and P stoichiometry in this area. There was no significant relationship between soil C, N, P stoichiometry and biodiversity indicators. **【Conclusion】** In the soil of three typical forest types in the hilly red soil region of southern China, the soil SOC, TN and TP contents of evergreen broad-leaved forest were higher, and the soil nutrients were relatively rich. However, the TP content in the study area was relatively scarce, and the forest vegetation was mainly inhibited by P element. The stoichiometric ratios of soil C, N, and P were affected by altitude, soil pH, vegetation type, and slope position. The growth of forest vegetation in this area is relatively strong, and the ecosystem is relatively healthy. These results will help to improve forest management and forest soil conservation management.