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区域湿地和农田土壤有机碳变化研究

——以长江中下游和安徽六安市为例

李典友 著

文匯出版社

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目　　录

区域湿地和农田土壤有机碳变化研究

——以长江中下游和安徽省六安市为例

摘　要

土壤有机碳(Soil Organic Carbon)含量是与植物生长及生态系统功能有关的关键土壤属性。土壤有机碳库是陆地生态系统中最活跃碳库,全球土壤有机碳库分别是大气圈和植被圈碳库的2~3倍,其消长动态直接影响到未来气候变化趋势。人类干扰下土壤碳库动态特征及其过程机制,已成为生态学、土壤学等学科的重点研究领域。

土壤有机碳库及其变化计量是土壤碳循环及固碳减排研究的重要科学内容。国内外研究表明,农田生态系统土壤碳库受到强烈的人为干扰,同时又可以在较短的时间尺度上进行人为调节。因此,土地利用变化和农业管理变化下中国农田有机碳库变化及其土壤固碳潜力的研究对于国家固碳减排战略及可持续农业发展途径选择具有重大科学意义。研究不同尺度的地理区域人为利用

中土壤有机碳储存及其变化特点成为土壤学、生态学和农业科学的研究热点。

本文以长江中下游地区特别是安徽省六安市域为对象,统计分析湿地和农业土壤在不同利用下的土壤有机碳变化,分析这种变化的空间尺度变异性,探讨影响土壤有机碳储存和积累的不同影响因素,期望为该区域农田土壤固碳和可持续土地利用及农业管理提供科学依据。研究的主要结果和认识如下:

长江中下游地区河流湖泊湿地开垦为农田,土壤有机碳库损失严重。长江中下游地区湿地分布广,存在着湿地开垦强度大、土壤碳密度较低和土壤有机碳损失严重等土壤碳库变化问题。与原湿地土壤相比,不同垦殖方式下土壤有机碳含量都有不同程度降低,而且随开发利用年限增长而加剧。不过,湿地垦殖为水田后土壤有机碳含量有稳定或略有提高的趋势,特别是江汉平原湿地和皖江平原湿地开垦为水田后,土壤有机碳含量可提高35%~67%。湿地垦殖为水田是一种相对较好的农业固碳利用方式。

皖江平原湿地表层土壤有机碳含量介于11.30~27.83 $g \cdot kg^{-1}$,且在土壤深层仍有较多的有机碳分布。围垦的农田土壤有机碳含量则明显降低,剖面深度分布的变异和地点间的变异远大于周边湿地。开垦为农田后,表层碳密度损失达18 $tC \cdot hm^{-2}$,全剖面达30 $tC \cdot hm^{-2}$。围垦损失的碳密度达到原湿地的40%以上。估算近50年来长江中下游地区湿地因垦殖导致的表土有机碳损失量为40~60 Tg C,而历史损失总计可能达0.15Pg C。

以六安市域为空间尺度研究了土壤有机碳含量随土地利用及空间尺度变化的变异状况。研究结果表明市域内表层土壤有机碳

含量表现非耕地土壤有机碳含量最高(12.27±2.90 $g\cdot kg^{-1}$)且变异系数最大(23.63%);水田土壤有机碳含量(11.50±1.08 $g\cdot kg^{-1}$)显著高于旱地土壤(8.11±1.17 $g\cdot kg^{-1}$)*,且变异系数(9.39%)也小于后者。市域内不同地貌单元上表土层有机碳平均含量表现为山地(14.60±3.14 $g\cdot kg^{-1}$)> 丘陵(13.20±3.26 $g\cdot kg^{-1}$)>岗地(10.22±1.00 $g\cdot kg^{-1}$)>平原圩畈(10.05±1.36 $g\cdot kg^{-1}$)。县级尺度上变异系数为5.31%~24.95%,乡镇尺度上变异系数在3.80%~16.75%,全六安市范围内变异系数为20.1%。说明研究区域内土壤有机碳含量存在高度的空间变异性,主要受土地利用、地形地貌和农业活动等多种因素的复杂影响。其中地貌因子在较大尺度(县域)上更影响明显,而农业活动在较小尺度上具有重要影响。

土壤有机碳含量还存在随土壤分类统计单元的变化。表层土壤有机碳含量土种内部的变异系数(4.29%~83.78%,平均值为44.04%)大于土种间的变异系数(32.00%);各土属间有机碳加权平均值为10.22($g\cdot kg^{-1}$),变异系数为43.03%。亚类为单元的有机碳变异系数可能大于较低分类单元的变异系数。自然土壤变异系数较大,例如广泛分布于山地的粗骨土亚类,有机碳含量最高(16.95±16.17 $g\cdot kg^{-1}$),变异系数达95.37%。而人为利用的土壤有机碳含量变异系数较低,漂洗型水稻土亚类仅11.97%。而亚类之间变异系数为58.75%。土类的有机碳变异性也极大,变异系数以山地酸性棕壤类最大,达95.42%,最小的是岗地砂姜黑土类,为18.92%。因此,以分类单元统计,土壤有机碳含量变异系数有随分类单元的级别而提高的趋势。这是所研究区域的地形地貌和土地利用共同决定的。由于土地利用影响体现在高级别单元,因此,

高级别分类单元统计有机碳含量变化将具有极高的变异性。

以市域内霍山县为对象,研究了耕地土壤有机碳含量随县域内不同尺度空间的变化。结果表明,20年来该县农田表土有机碳含量明显提高,显示农田土壤的有机碳库积累,同时有机碳空间变异系数总体降低。例如,土种间有机碳含量的平均变异系数由1985年的48.62%降低到2005-2008年的14.64%。县域范围内耕地土壤有机碳含量的不同尺度的变异系数介于4.53%~14.91%,因不同尺度空间而异。研究结果表明村民组(自然村)尺度单元内有机碳含量的变异性最高,乡镇间有机碳含量变异性低于行政村间变异性。因此,从县级尺度的农田土壤碳库计量来说,以乡镇尺度采样研究比村级尺度的可靠性较高。影响县域内农田土壤有机碳含量与变异的动力因子主要是农业利用和农田基本建设,栽茶和种植水稻方式下农田土壤有机碳含量明显较高。在县域空间范围内,农业管理措施对农田有机碳含量产生的显著影响。

因此,土壤有机碳随土地利用和农业管理的变化因空间和时间而异,区域土壤有机碳变化动态与生态系统功能、农业生产力的关系尚需要深入的研究。未来农业发展和气候变化下区域土壤碳库变化及不同人类活动的影响将仍是今后研究的课题。特别是定量分析表征气候变化、土地利用变化、人类活动强度及耕作管理对农田土壤有机碳收支的相互作用影响是区域土壤有机碳研究需要充分重视的领域。

关键词:土壤有机碳;农田土壤;湿地;空间变异性;长江中下游;六安市;统计分析

SOIL ORGANIC CARBON DYNAMICS OF WETLANDs AND CROPLANDs --A CASE STUDY OF LOW YANGTZE VALLEY AND LU'AN DISTRICT OF ANHUI PROVINCE, CHINA

ABSTRACT

Soil Organic Carbon is one of the key properties which have closely relationship with ecosystem functions and plant growth. Soil organic carbon pool, which is 2 to 3 times larger than the pool s of atmosphere and vegetation, is the most active pool in terrestrial ecosystems, and its dynamic will affect future climate change trends directly. The dynamic of soil carbon pool and its process mechanisms under human disturbance, has become the key research areas of ecology, soil science and other disciplines.

The dynamic of soil organic carbon pool and its quantification are important contents for studying the carbon cycling and carbon sequestration. Domestic and international researches showed that soil carbon pool in cropland was disturbed strongly by agricultural managements, while it could be adjusted by human in a short time. Therefore, there will be an important scientific significance in carbon

sequestration strategies and the options of sustainable agricultural development paths of China for the studies of SOC dynamics and its sequestration potential under landuse changes and agricultural managements. The studies of SOC dynamics under different scales of geographical regions have become the research focuses of soil science, ecology and agricultural science.

This thesis studied the SOC dynamics of wetlands and croplands in the Yangtze River region in Lu' an city, Anhui province, and also analyzed the SOC variability of spatial scale, in order to explore the factors which impacted storage and accumulation of SOC and provided the scientific basis for SOC sequestration, land use sustainable and agricultural managements in this region. The main results are as follows:

1. The soil in the regions of Yangtze River lost SOC seriously when the wetlands were reclaimed as croplands. Yangtze River wetlands, which were reclaimed deeply and had low SOC contents, were distributed widely. Compared with the original wetland soils, the soils under different cultivation methods have different decrements of SOC contents, and these decrements increased with the increments of the utilization years. However, there was a little increment in SOC when the wetlands were reclaimed as rice paddies. The SOC contents were increased by 35% ~ 67% when the wetlands in Jianghan Plain and Wanjiang Plian wre reclaimed as the rice paddies. Therefore, wetland is reclaimed as rice paddy is one of the well approaches in carbon sequestration.

2. The SOC contents in Wanjiang Plain wetland distributed between 11.30 to 27.83 $g \cdot kg^{-1}$, and there were still much SOC in deep soil. The SOC in wetlands reclaimed showed a decrease trend, and its distribution among the regions and soil deeps showed more variability than other wetlands. After reclaimed as croplands, the soils lost the SOC as 18 $tC \cdot hm^{-2}$ in topsoil and 30 $tC \cdot hm^{-2}$ in total soils, respectively. The SOC density of wetlands cultivated were only 40% of original. The loss of SOC storage estimated as 40 ~ 60TgC in recent 50 years, and 0.15PgC in history.

3. The SOC content variation with the landuse and spatial changes in Lu´an was studied in this study. The results show that the SOC content (12.27±2.90 $g \cdot kg^{-1}$) and coefficient of variation (23.63%) in uncultivated soil was highest in all the soils of Lu'an City; SOC content of paddy soil (11.50±1.08 $g \cdot kg^{-1}$) was significantly higher than that of dryland soil (8.11±1.17 $g \cdot kg^{-1}$), and the coefficient of variation (9.39%) is less than the latter. The topsoil SOC in different landscape units were Mountain (14.60 ± 3.14 $g \cdot kg^{-1}$) > hill (13.20 ± 3.26 $g \cdot kg^{-1}$) > hillock (10.22 ± 1.00 $g \cdot kg^{-1}$) > Plain Wei Fan (10.05 ± 1.36 $g \cdot kg^{-1}$). Under county scale, the coefficient of variation was between 24.95% and 5.31%, 3.80% to 16.75% under township scale, 20.1% in the whole range of Lu'an city. It indicated that there was a high degree of spatial variability in SOC content in this region, which mainly due to land use, topography, agricultural activities and the complexity of other factors. Topography factor

affected more obviously than others under the larger landscape scale (county), but agricultural activities had the important influence in smaller scale.

4. There were some differences in SOC content among soil classifications. The coefficient of variation in SOC within soil species (4.29% ~ 83.78%, average 44.04%) is greater than that among soil types (32.00%); the soil organic carbon is a weighted average of 10.22 ($g \cdot kg^{-1}$), and coefficient of variation was 43.03% among soil classifications. Coefficient of variation in SOC under sub-class as a unit may be greater than that under lower taxa. Coefficient of variation (95.37%) among natural soils (e. g. widely distributed in the mountainous sub-soil and thick bone) showed larger than others, and also with the highest SOC ($16.95 \pm 16.17\ g \cdot kg^{-1}$). The soil SOC of human use soils showed a lower coefficient of variation, with 11.97% only by rinse paddy soils sub-class. The coefficient of variation among sub-class was 58.75%. The coefficient of variation in SOC among soil types was also great, with the highest in mountain acid brown type (95.42%), and with the smallest in mound lime concretion black soil type (18.92%). Therefore, in taxa statistics, coefficient of variation of soil organic carbon content had the rising trend with the changes of taxa levels, which was determined by the topography of the study area, joint decisions and land use. Because the land use impact is reflected in the high-level unit, therefore, the SOC among the high-level taxa had a very high variability.

5. We studied the changes of SOC content with the different scales in Huoshan County. The results showed that the SOC in the county′s cropland showed an increase trend in recent 20 years, which indicated that soil organic carbon accumulated in this region ' s croplands, while the overall coefficient of variation of SOC showed a reduced trend. For example, the coefficient of variation of SOC content among species decreased from 48.62% in 1985 to 14.64% in average between 2005 and 2008. Within the county, the SOC content coefficient of variation was between 4.53% ~ 14.91%, which induced by different scales of space. The results also showed that among the village group (villages) scale, variability of SOC was max; variability of SOC among township was lower than that among villages. Therefore, from the county scale for the quantification of cropland SOC, the town scale was more reliability than the village-scale. The impact factors of the changes of SOC content and its variability in county were mainly agricultural use and farmland capital construction. The soils planted tea and rice has the higher SOC. The SOC was effected significantly by agricultural management under county scale.

Therefore, soil organic carbon changes with land use and agricultural management due to different space and time, the relationship between soil organic carbon dynamic, ecosystem function and agricultural productivity is still a need for advanced. The change of the regional soil carbon pool and the effects of human activities will continue to be the subject of future research under future agricultural