Environmental effects and relationship between soil organic matter and total nitrogen in Lushan Mountain, China

Yingjun MA
College of Resources and Environmental Sciences, Nanjing Agricultural University, Nanjing, Jiangsu Province, 210095, China
Corresponding author: 455129227@qq.com

Abstract. The content of soil total nitrogen (STN) and soil organic matter (SOM) is important in soil fertility. We analysed four typical soils (red soil, yellow soil, yellow brown soil and brown soil) in Lushan Mountain area to clarify the environmental effects and relationship between STN and SOM. The results showed that there was a significant correlation between soil organic matter and total nitrogen in Lushan soil, which can be established by stepwise regression analysis. SOM and STN may have negative impacts on the growth of plants on the red soil and high STN may lead the underground water into eutrophication. This study is of positive significance for understanding the correlation between soil nutrients, rational development and utilization of soil nutrients in Lushan Mountain.

1. Introduction
Soil is an important constituent of the biosphere of earth, and also the foundation of agriculture and natural ecosystem. Soil organic matter is an important index reflecting soil fertility, and it is also the research focus of agrology. STN is an important index for evaluating soil quality, which is closely related to crop yield and quality. Only when the soil organic matter and total nitrogen are fully understood can fertilization be scientifically applied[1]. For chemical determination, soil organic matter determination is simpler, as more than 30 samples can be measured in a day, while Kjeldahl method costs two to three hours just to digest. Nitrogen in soil exists mainly in the form of organic nitrogen[2]. Therefore, there is a certain relationship between content of soil total nitrogen and soil organic matter[3]. If an appropriate quantitative expression can be put forward, the content of soil total nitrogen can be calculated from the results of soil organic matter measurement, which has certain significance for soil fertility diagnosis[4].

Researchers have done a lot of research on the content of nutrients in Lushan soil and correlation of different nutrients. Wu[5] believed that the content of available potassium in Lushan soil was positively correlated with the content of organic matter. Wang Zhen[6] considered that the content of soil organic matter and total nitrogen in Lushan soil were positively correlated with altitude. However, the correlation between soil organic matter and soil total nitrogen in Lushan soil has rarely been reported.

In this study, soil organic matter and total nitrogen in four soil genetic layers of Lushan red soil, yellow soil, yellow brown soil and brown soil were determined, and the correlation between soil organic matter and total nitrogen in four soil layers was analyzed. In addition, we forecasted possible environmental effects of soil organic matter and total nitrogen in Lushan Mountains, and some suggestions on the fertility diagnosis of Lushan soil were put forward, which will promote the rational exploitation and utilization of Lushan soil.
2. Materials and methods

2.1. Study area
The study was conducted in Lushan Mountain. Lushan Mountain is located in the suburb of Jiujiang City, in the north of the Yangtze River and in the south of Poyang Lake, with an elevation of 1474 meters[7]. The mean annual precipitation in Lushan area is 1300-1600 mm. Forty percent of the precipitation is concentrated in summer. Heavy rain occurs frequently in early July[8].

Lushan soil has obvious zonality because of its unique formation process and geographical location. According to the geographical location and vegetation distribution characteristics of Lushan Mountain, the soil distributed in the horizontal zone of Lushan Mountain is mainly red soil. However, with the increase of altitude, biological and climatic changes in turn, soil types show obvious vertical zonal characteristics. Soil types from bottom to top were red soil, yellow soil, yellow brown soil, brown soil[6].

2.2. Test Soil
Following the principles of representativeness, typicality and convenience, four soil samples (red soil, yellow soil, yellow brown soil and brown soil) were collected in Lushan Mountain of Jiangxi Province in July 2018.

Red soil: It was collected from the foot of Lushan Mountains near Sai yang Town at an elevation of 200 meters, ferric bauxite class, mainly composed of quartz sandstone, granite and other weathered residues and slope sediments. It has a distinct process of desilication, iron and aluminum enrichment, and the vegetation is evergreen broad-leaved forest[9].

Yellow soil: It was collected from 940 meters above sea level near Xianrendong in Lushan Mountain. The parent material is the residual material of slope, which has obvious yellowing process. The vegetation is a mixed forest of subtropical evergreen conifer and broad-leaved forest, and part of it is deciduous broad-leaved forest.

Yellow-brown soil: It was collected from the forest near the old site of Lushan Conference, which is about 990 meters above sea level. Its parent material is mainly aeolian material. It has the process of weak desilication and iron-rich alienization. The vegetation is evergreen deciduous broad-leaved mixed forest.

Brown soil: It was collected from an elevation of 1170 meters near Xiaotianchi, the parent material is mainly the residue of sandstone and slate, which has a strong process of leaching and sticking, and the vegetation is deciduous broad-leaved forest.

2.3. Sample Collection and Processing
For surface soil, individual samples were collected. In order to ensure the representativeness of samples, 3-7 sampling areas were set up for each soil unit. When collecting deep soil, excavate soil profile. The section length, width and depth were generally 1.5 meters, 0.8 meters and 1.2 meters. Soil layers were divided according to the colour, texture, structure and root system of soil profile. The amount of each sampled layer was 1.5 Kg[10].

Samples were spread out, crushed and stirred. Impurities such as gravel and plant residues were picked out. All the samples were passed through 0.25-mm sieves. The roughly ground samples were divided into two parts by quartering, one for retention and the other for fine grinding. It is grinded to 100 mesh sieves for the analysis of soil elements. After grinding and mixing, the samples were separated into sample bags and filled in the soil label[11].

2.4. Determination Method
Soil organic matter was determined by potassium dichromate method, and soil total nitrogen was determined by semi-micro Kelvin method[12].
2.5. Analytical Method

SPSS 16.0, Excel 2016 and other software were used to process data and make correlation analysis.

3. Results and discussions

3.1. Content of soil organic matter and total nitrogen in soil

The results of soil organic matter and total nitrogen in red soil, yellow soil, yellow brown soil and brown soil in Lushan area were shown in Table 1. The content of soil organic matter in three soil genetic layers A, B and C of red soil was 15.69 g/kg, 18.14 g/kg and 5.47 g/kg, which of yellow soil is 41.68 g/kg, 35.07 g/kg and 31.85 g/kg. The content of soil organic matter in A and B layers of yellow brown soil was 79.29 g/kg and 9.18 g/kg respectively. The content of soil organic matter in brown soil was 81.69 g/kg and 31.3 g/kg, respectively. The content of SOM and STN differed significantly (P < 0.05) between different soil types. It can be seen in Figure 1 that the content of soil organic matter in Lushan soil is basically layer A > layer B except for red soil. This may be due to the high vegetation coverage and litter on the soil surface decomposed into a large amount of humus. In addition, litter reduces the leaching of soil organic matter. Therefore, the content of soil organic matter in layer A was significantly higher than that in layer B. But at low altitude, microbial decomposition rate increases greatly in warm and humid environment, and soil organic matter is decomposed in large quantities, so the content of organic matter in layer A of red soil is lower than that in layer B[13].

Table 1. Content of soil organic matter and soil total nitrogen in soil from Lushan Mountain

| Soil type          | Soil genetic layers | Organic matter (g/kg) | Total nitrogen (g/kg) |
|--------------------|---------------------|-----------------------|-----------------------|
| Red Soil           | A                   | 15.69c                | 0.59c                 |
|                    | B                   | 18.14c                | 1.01b                 |
|                    | C                   | 5.47c                 | 0.17d                 |
| Yellow Soil        | A                   | 41.68b                | 1.04b                 |
|                    | B                   | 35.07b                | 0.66c                 |
|                    | C                   | 31.85b                | 1.28b                 |
| Yellow Brown Soil  | A                   | 76.29a                | 3.05a                 |
|                    | B                   | 9.18c                 | 0.42c                 |
| Brown Soil         | A                   | 81.69a                | 3.22a                 |
|                    | B                   | 31.3b                 | 1.46b                 |

Different characters in a single column indicate significant difference between the treatments at p < 0.05. As shown in Figure 1, the content of soil organic matter increased significantly with the increase of altitude. It may be due to the temperature, microbial physiological activity and mineralization, so soil organic matter can be accumulated[14].

The content of total nitrogen in three layers of red soil was 0.59 g/kg, 1.01 g/kg and 0.17 g/kg respectively, while that in yellow soil was 1.04 g/kg, 0.66 g/kg and 1.28 g/kg. The content of total nitrogen in A and B layers of yellow brown soil was 3.05 g/kg and 0.42 g/kg, respectively. The content of total nitrogen in brown soil was 3.22 g/kg and 1.46 g/kg. Compared with Figure 1 and Figure 2, the distribution of soil organic matter and total nitrogen in Lushan soil is almost the same. The distribution pattern of the content of soil total nitrogen in layer A is red soil < yellow soil < yellow brown soil < brown soil, which may be closely related to precipitation, temperature, vegetation characteristics and soil texture in Lushan[15,16]. Too much water leads to the anaerobic process and the decreasing of decomposition rate of soil organic matter. The viscous texture has poor ventilation. It not only inhibits the activity of microorganisms and enzymes, but also reduces the availability of organic matter due to the protection of clay. Therefore, soil with poor drainage or heavy texture often contains more organic matter and nitrogen than soil with good drainage or light texture and coarse texture. The analytical results of the soils were in agreement with this conclusion. Brown soil is loamy clay with heavy texture, rich rainfall and high moisture, so its content of soil organic matter and total nitrogen is the highest.
The same as the distribution of soil organic matter, except for red soil, the distribution of the content of total nitrogen in Lushan soil is basically layer A > layer B. This may be due to the fact that most of the nitrogen in the soil is in organic form. Inorganic forms of nitrogen generally account for 1%-5% of total nitrogen. Atmospheric precipitation brings only a small proportion of total nitrogen to the soil and the content of nitrogen in soil parent material is also very small. Therefore, soil organic matter is the dominant factor and the most direct factor affecting nitrogen supply. Other factors affect content of nitrogen by affecting the accumulation and decomposition of soil organic matter[17].

The content of soil organic matter and total nitrogen in brown soil was the highest, which may be due to the high vegetation coverage and flourishing growth of brown soil. This can provide abundant plant residues to the soil every year. In addition, the sampling site of brown soil is located near Xiaotianchi Lake with an elevation of 1170m, which has cold climate and microbial decomposition activities is inhibited. Therefore, brown soil has high content of soil organic matter and a deep humus layer[18].
3.2. Correlation analysis of soil organic matter and total nitrogen
As shown in Figure 3, the correlation between content of soil organic matter and total nitrogen in different soil layers of Lushan Mountains is extremely significant and the correlation between them reaches 0.9024 through statistical analysis of experimental data. The data show that soil organic matter generally contains about 4% nitrogen. And the conversion coefficient between content of soil organic matter and soil total nitrogen in Lushan is 0.01112 - 0.06390[19]. The results of Figure 3 suggest that content of soil total nitrogen in Lushan soil can be roughly estimated from the content of soil organic matter by using the regression equation.

![Figure 3. Fitting diagram of correlation between soil organic matter and soil total nitrogen](image)

\[
y = 0.0381x - 0.0298 \\
R^2 = 0.9024
\]

3.3. Prediction of environmental effects of total nitrogen in Lushan soil
Lushan Mountain is rich in biological resources because of its unique geographical environment. However, according to the measured content of soil total nitrogen, the lack of nitrogen may have an impact on its richness of biological resource. The soil pH is low especially in the red soil region of mountain, and the content of soil organic matter and total nitrogen is lower than the average level. Without human intervention, it may not be suitable for plant growth.

Nitrogen is the main limiting element in water eutrophication[20]. Soil nitrogen may leach into groundwater and eventually cause serious impact on surface water environment, resulting in eutrophication of surface water and deterioration of water environment. Lushan area is rich in water resources with abundant precipitation, surface water and even groundwater. However, recent studies have shown that the water body of Lushan Mountain is partially polluted, and eutrophication occurs. Dayueshan Reservoir and Lulin Lake are the main drinking water sources in Lushan Mountains. Research shows that the water quality of Dayueshan Reservoir is clean, while Lulin Lake has been lightly polluted. But the water quality of other points has been polluted to varying degrees, and most of the organic matter indexes in water exceed the standard. For example, the indexes of COD, T-N and T-P in the Donggu stream of Qinhu Lake and Hydropower Station Reservoir exceed the water quality standard by 2-8 times, and some water bodies have already experienced eutrophication[21]. Although the main source of eutrophication of nitrogen and phosphorus in water body is domestic sewage, soil nitrogen loss are also an important source. Lushan area has abundant precipitation and serious soil leaching, and the content of total nitrogen in yellow brown soil obtained from experiments is very high. If the leaching is serious, it will have a serious impact on water body.
4. Conclusion
In this paper, the content of soil organic matter and total nitrogen in different elevations and layers of soil (red soil, yellow soil, yellow brown soil, brown soil) in Lushan Mountain were studied, and the relationship between them and elevation was analyzed. The regression equation of organic matter and total nitrogen in Lushan Mountain soil was established. The following conclusions were drawn:

1. The distribution pattern of total nitrogen and soil organic matter in A layer of Lushan soil is red soil < yellow soil < yellow brown soil < brown soil. With the increase of altitude, the content of soil organic matter and total nitrogen increased.

2. The same as the distribution of content of soil organic matter, except for red soil, the distribution of total nitrogen content in Lushan soil is basically layer A > layer B.

3. There is a significant positive correlation between organic matter and total nitrogen content in four kinds of soils in Lushan Mountain. The regression equation is:

   \[ y = 0.0381x - 0.0298 \quad (R^2 = 0.9024) \]

   Therefore, using the regression equation, the content of total nitrogen in Lushan soil can be roughly estimated by measuring the content of soil organic matter. There are many factors affecting soil nutrients, such as climate factors, vegetation coverage and density, vegetation types and composition (leguminous and non-leguminous forages), plant uptake, degradation of animal and plant residues, human factors (including grazing and its effects), animal behavior, microorganisms [15,16,17]. In addition, nitrogen supply has a direct impact on plant growth, so reasonable tillage and fertilization should be adopted in the production process. If nitrogen is excessive, soil nitrogen enters groundwater through leaching, which increases the content of ammonium nitrogen in groundwater, thus affecting the quality of groundwater. The experimental data were contingent and the impact of nitrogen on the environment, especially on water quality, should be verified by experiments, which need to be further studied.

Acknowledgements
I sincerely thank Chen Xiaoyun, Zhang Xuhui, Liu Manqiang and other teachers for their guidance during Lushan internship. I also thank Mr. Yang for his explanation and guidance in this semester. I would like to thank my partners during the experiment and the class leaders for data collation later.

References
[1] Lin Wanshu. Study on the correlation between nitrogen, phosphorus, potassium and organic matter in garden soil of Gutian County [J]. Agricultural Technology Promotion in China, 2014, 30 (09): 35-37+46.
[2] Gai Xiapu, Liu Hongbin, Zhai Limei, Yang Bo, Ren Tianzhi, Wang Hongyuan, Wu Shuxia and Lei Qiuliang. Effects of long-term application of organic manure/straw returning on soil nitrogen leaching risk [J]. Agricultural Science of China, 2018, 51 (12): 2336-2347.
[3] Huangting, Zhou Jiheng, Li Qiang, Wang Yujun, Zhang Zhuo. Distribution of pH value of tobacco-growing soils at different altitudes and its relationship with soil nutrients --- Taking Qujing City, Yunnan Province as an example [J]. Soil Bulletin, 2015, 46 (01): 105-110.
[4] Guo Chengfen. Study on the relationship between total nitrogen and organic matter content in soils of Suzhou City [J]. Journal of Anhui Agricultural University, 1996 (04): 33-34.
[5] Wu Chenyuan. The relationship between soil organic matter and available potassium in Lushan [J]. Modern Agricultural Science and Technology, 2018 (11): 186-187.
[6] Soil nutrient content and vertical distribution characteristics of Wangzhen Lushan [J]. Anhui Agricultural Science, 2018, 46 (13): 132-135.
[7] Distribution characteristics and influencing factors of trace elements in soils of Guan Xueqing and Wu Hao-Lushan [J]. Modern Agricultural Science and Technology, 2008 (09): 102-103+105.
[8] Zhang Yuan, Wei Hongfei, Lushan Institute of Tea Sciences Tea Farm Physical and Geographical Environment Analysis and Tea Garden Construction Strategy [J]. Chinese Tea, 2018, 40 (10): 16-19.

[9] Study on the profile and nutrient status of red soil in Xiejohn Lushan area [J]. Anhui Agricultural Science, 2016, 44(06): 169-170.

[10] Li Jian, Fan Xuezhen. Thoughts on Soil Sample Collection in Quality and Safety Testing of Agricultural Products [J/OL]. Modern Agricultural Science and Technology, 2018 (22): 197-199 [2018-12-10].

[11] Miao Wanqiang. Research progress in soil collection, preparation and sample pretreatment methods [J]. Heilongjiang Environmental Bulletin, 2017, 41(02): 65-68.

[12] Wang Jian. Semi-micro Kaiser method for determination of nitrogen in coal [J]. Shandong Industrial Technology, 2016(21): 80.

[13] Li Zhongpei, Cheng Lili, Lin Xinxiang. Change characteristics of humus composition in red soil and its relationship with fertility evolution [J]. Soil, 2002 (01): 9-15.

[14] Shang Bin, Zou Jing, Xu Yimin, Song Wenjing, Wang Chengdong, Meng Lin, Liu Xiaobing, Zhu Zhiguang. The relationship between organic matter content of tobacco-growing soils and elevation and parent materials in the central mountainous areas of Guizhou [J]. Soil, 2014, 46 (03): 446-451.

[15] Wang Changting, Long Ruijun, Wang Qiji, Jing Zengchun, Shanghuan, Ding Luming. Distribution and productivity changes of soil organic matter nitrogen and phosphorus at different elevation gradients in alpine meadow and their relationship with environmental factors [J]. Journal of Grassland Science, 2005 (04): 15-20.

[16] Hidden treatments in ecological experiments: re-evaluation of the ecosystem function of biodiversity [J]. Michael A. Huston. Oecologia. 1997 (4)

[17] Zhao Yun, Chen Wei, Li Chunming, Chen Jiangang, Zhang Dequan. Soil organic matter content and its relationship with main nutrients in alpine meadows with different degradation degrees in the East Qilian Mountains [J]. Grassland Science, 2009, 26 (05): 20-25.

[18] Zhang Fenglong. Soil Geography. China Agricultural Press, 2002. 98-99.

[19] Chen Wei, Yang Guofeng, Zhao Yun, Zhang Miaomiao, Sun Juan, Zhang Dequan. Soil organic matter and total nitrogen content and their correlation in different habitats of Jinfo Mountain [J]. Grassland Science, 2009, 26 (06): 25-28.

[20] Schindler D W. Evolution of phosphorus limitation in lakes [J]. Sciences, 1997, 195: 260-262

[21] Evaluation of Environmental Quality of Lushan Waters by Huang Huibai, Wang Jianguo and Tang Zhenhua Index 2002. 22(5): 416-420