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Evaluation of soil nutrients about typical economic forest lands of low hilly areas in eastern part of Zhejiang Province

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Abstract. Through sampling of seven economic forest lands in low hilly areas of Zhejiang province the samples were tested, including soil organic matter, total nitrogen, available phosphorus and available potassium. The characteristics of soil nutrients in different economic forest lands were analysed by statistical method and the comprehensive evaluation of soil nutrient quality was carried out. The results showed that there were differences in soil nutrient contents in different economic forest lands. The overall status of soil nutrients in the economic forest land is in the "good" level; Among them, the content of soil organic matter and total nitrogen in the economic forest land were relatively abundant, However, the content of available potassium in soil was not enough, which was the main limiting factor for the development of economic forest land.

1. Introduction

Soil is an important part of terrestrial ecosystem, which is one of the main conditions for human survival [1]. The most important role of the soil is to provide nutrients and water for plants, and the change of land use has a variety of effects on soil nutrients. It is important to study the characteristics of soil nutrients in different land use patterns in order to understand the maintenance of soil fertility [2]. Soil fertility is the comprehensive performance of various basic properties of soil, how to quantitatively characterize soil fertility and its evaluation has become one of the hot spots of scientists in the world [3]. At present, there were many researches on the comprehensive evaluation of soil quality, such as the evaluation of forest soil quality [4], urban green land soil quality [5], the nursery land soil quality [6], agricultural land soil quality [7], etc. The evaluation methods mainly involved clustering analysis, factor weighting, Nemero comprehensive index method [8-10]. In this study, the low hilly area in southeast of Zhejiang was selected as the study area. Soil samples were collected in the main economic forest lands, the soil organic matter, soil total nitrogen, soil available phosphorus and soil potassium nutrient index were tested to analysis of soil nutrient characteristics. Comprehensive evaluation of soil nutrient level was carried out by using the improved Nemero comprehensive index method. The study can provide reference for the management of land in the low hilly area of Zhejiang province.

2. Materials and Methods

In this study, according to the land use types of low hilly area, seven representative economic forest land distributed in four towns (including Myrica rubra, Phyllostachys heterocycla, Camellia sinensis, Acer palmatum Thunb, Cerasus yedoensis, Cerasus pseudocerasus and Grassland), totally eighteen plots were study. In each plot, Sampling according to S-type principle, three-point sampling for mixing (sampling depth 0-20cm). Then, the mixed soil sample into the bag, and brought back to the laboratory to dry, pick root, grinding and sieving standby. The mineral nutrients which can be absorbed directly or transformed by the plant roots are called soil nutrients, which are mainly derived from soil minerals, soil organic matter and fertilization. It is generally believed that the soil organic matter content, total nitrogen, available phosphorus and available potassium in soil are important reflection of soil nutrient status. Therefore, this study is mainly aimed at these four indicators. Preliminary analysis of the test data in the Excel, the relevant statistical data analysis using SPSS software, the required graphics using Origin drawing software. In this study, the soil nutrient classification standard in the second soil survey in China was adopted. At the same time, combined with the actual situation in the low hilly area, the soil organic matter, soil total nitrogen, soil available phosphorus, soil available potassium was divided into four levels according to table 1.

Table 1. Gradation standard of soil nutrient index

Soil nutrient index	X_{imin}	X_{imid}	X_{imax}
Soil organic matter /g·kg^{-1}	5	10	20
Soil total nitrogen /g·kg^{-1}	0.5	0.8	1.2
Soil available phosphorus /mg·kg^{-1}	5	10	20
Soil available potassium /mg·kg^{-1}	50	90	150

In this paper, the evaluation methods of different kinds of soil nutrients were the improved Nemero comprehensive index method [11]. The calculation method of single soil nutrient index is as follows:

$$P_i = \begin{cases} X_i / X_{imin} & (X_i \leqslant X_{imin}) \\ 1 + (X_i - X_{imin})/(X_{imid} - X_{imin}) & (X_{imin} < X_i < X_{imid}) \\ 2 + (X_i - X_{imid})/(X_{imax} - X_{imid}) & (X_{imid} < X_i < X_{imax}) \\ 3 & (X_i > X_{imax}) \end{cases}$$

Where P_i is single soil nutrient index. X_i is the value of soil nutrient test value. X_{min}, X_{mid}, X_{max} are the corresponding value of the gradation standards, respectively. i is evaluation index number (i = 1,2,3,4). Comprehensive index of soil nutrients was used to evaluate soil nutrient status of certain economic forest land. the calculation method is:

$$Q = \sqrt{\frac{(\bar{P}_i)^2 + (P_{imin})^2}{2}} \frac{(n-1)}{n}$$

Where Q is a certain kind of soil nutrient index. $\bar{Pi}$ is the average value of soil nutrient index. P_{imin} is the minimum value of soil nutrient index. n is soil nutrient index number (n = 1,2,3,4). In this formula, using the P_{imin} instead of the P_{imax} in the Nemero formula. And to increase the correction $(n - 1)/n$. On the one hand, the focal point is made to stand out impact of the worst soil nutrient factors on soil nutrient quality. And this reflected rules of minimum biological growth factor. On the other hand, the more factors, the greater the correction value, the higher the credibility. Table 2 showed the gradation standard of soil nutrient comprehensive index.

Table 2. Gradation standard of soil nutrient comprehensive index

Gradation	I	II	III	IV
Range of Q	≥ 2	1.5 - 2.0	1.0 - 1.5	< 1.0
Quality review	excellent	good	qualified	bad

3. Results and Analysis

3.1 Soil organic mater

Soil organic matter refers to the carbonaceous organic matter in soil. Including a variety of animal and plant residues, microorganisms and various organic compounds which decomposed and compounded by them. Soil organic matter is not only the source of mineral nutrition and organic nutrition, but also the energy source of heterotrophic microorganisms in soil. At the same time, it is also an important factor in the formation of soil structure. The content of soil organic matter, to some extent, reflects the fertility of the soil. Figure 1a reflected the characteristics of soil organic matter in different economic forest land. The characteristics of soil organic matter of seven typical economic forest land was the characteristics of soil organic matter of seven typical economic forest land was Acer palmatum Thunb (72.57 g·kg^{-1}) > Cerasus yedoensis (68.79 g·kg^{-1}) > Camellia sinensis (58.81 g·kg^{-1}) > Myrica rubra (55.72 g·kg^{-1}) > Phyllostachys heterocycla (55.55 g·kg^{-1}) > Cerasus pseudocerasus (47.46 g·kg^{-1}) > Grassland (37.15 g·kg^{-1}). The average soil organic matter content of Acer palmatum Thunb was 1.95 times that of Grassland. There were also differences in soil organic matter in different regions. For example, soil organic matter content (62.60 g·kg^{-1}) of Myrica rubra forest land in Zhangting town was more than that (52.28 g·kg^{-1}) in Mazhu town.

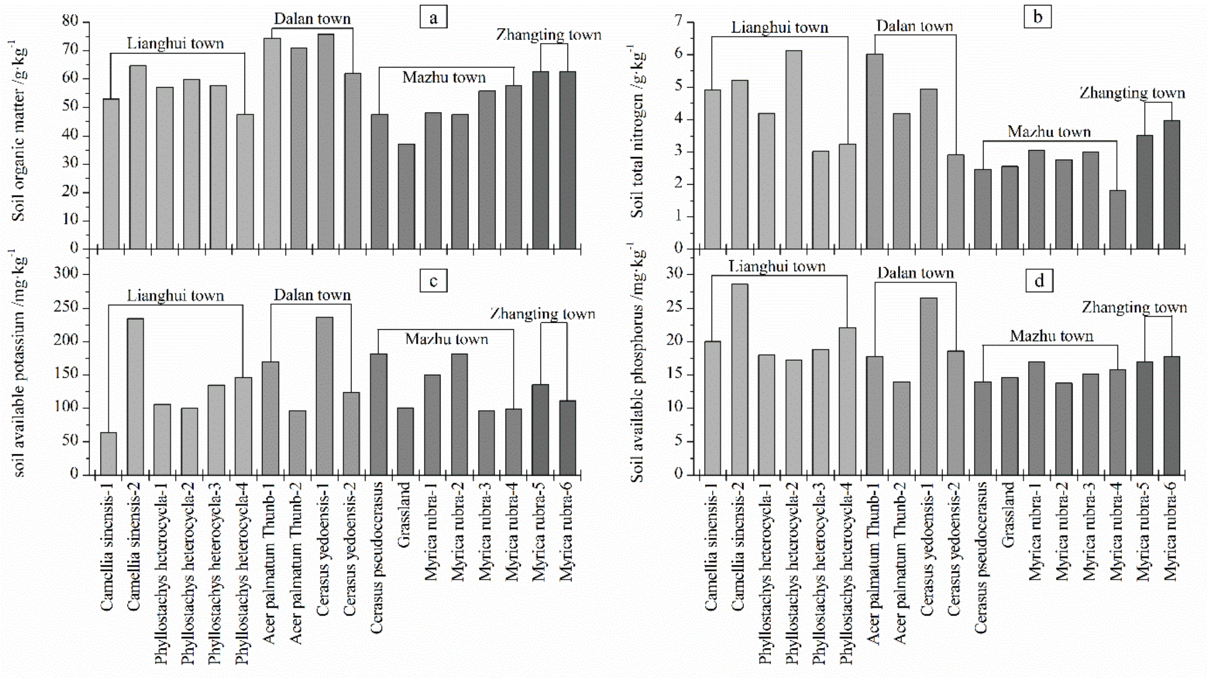

Figure 1. Soil nutrients content of different economic forest land

The difference of soil organic matter content in different economic forest land was caused by vegetation type, human disturbance, litter composition and decomposition. because of artificial interference less, Acer palmatum Thunb forest land, Cerasus yedoensis forest land and Camellia sinensis land had more litter and residues of animal and plant. decomposition of humus improved organic matter content in soil. in contrast, Phyllostachys heterocycla forest land and Myrica rubra forest land had lower soil organic matter content because of the artificial removal of understory vegetation and litter.

3.2 Soil total nitrogen

Most of the nitrogen in the soil exists in organic form, and the organic nitrogen is transformed into inorganic nitrogen for crop absorption and utilization under the condition of cultivation and so on. Organic and inorganic nitrogen in soil come to be known as soil total nitrogen. As can be seen from figure 1b, the total nitrogen content of soil was also affected by the type of economic forest, there are obvious differences. The content of total nitrogen in different economic forest land was Acer palmatum Thunb (5.10 g·kg^{-1}) > Camellia sinensis (5.06 g·kg^{-1}) > Phyllostachys heterocycla (4.15 g·kg^{-1}) > Cerasus yedoensis (3.93 g·kg^{-1}) > Myrica rubra (3.02 g·kg^{-1}) > Grassland (2.56 g·kg^{-1}) > Cerasus pseudocerasus (2.46 g·kg^{-1}). The soil total nitrogen content of Acer palmatum Thunb forest land was 2.08 times that of Cerasus pseudocerasus forest land. There were also differences in soil total nitrogen content of different regions. For example, soil total nitrogen content (3.74 g·kg^{-1}) of Myrica rubra forest land in Zhangting town was more than that (2.65 g·kg^{-1}) in Mazhu town. The content of total nitrogen in soil was related to the source of nitrogen and the absorption and utilization of plants. The main sources of soil total nitrogen form soil humus, animal and plant and microbial residues, organic fertilizer. Its absorption was closely related to plant type. Bamboo shoots absorb a large amount of soil inorganic nitrogen, but because of artificial fertilization, the total nitrogen content in soil was not the lowest. Grassland due to not external source of nitrogen, the total nitrogen content in soil was lowest. Because of large litter nitrogen return, soil total nitrogen content of Acer palmatum Thunb forest land and Camellia sinensis forest land were higher.

3.3 Soil available potassium

According to the potassium existing form and potassium uptake by crops, it can be divided into water soluble potassium, exchangeable potassium and stationary potassium in clay minerals. The first two potassium can be absorbed and utilized by the crop, them were referred to as available potassium. As can be seen from figure 1c, the relationship of soil available potassium in different economic forest land was Cerasus pseudocerasus (181.63 mg·kg^{-1}) > Cerasus yedoensis (180.33 mg·kg^{-1}) > Camellia sinensis (148.86 mg·kg^{-1}) > Acer palmatum Thunb (132.84 mg·kg^{-1}) > Myrica rubra (128.77 mg·kg^{-1}) > Phyllostachys heterocycla (121.83 mg·kg^{-1}) > Grassland (100.60 mg·kg^{-1}). The average soil available potassium content of Cerasus pseudocerasus was 1.81 times that of Grassland. There were some differences in soil t available potassium content of different regions. For example, soil available potassium content (123.33 mg·kg^{-1}) of Myrica rubra forest land in Zhangting town was less than that (131.49 g·kg^{-1}) in Mazhu town. There are many factors affecting soil available potassium, such as fertilization, matrix, climate and land use. Due to the limited conditions, the analysis of the above-mentioned factors is not enough, such as vegetation coverage, cropping system and the distribution of residential areas, these factors impact of soil available potassium content, is worthy of further study.

3.4 Soil available phosphorus

The soil available phosphorus is the phosphorus in soil which can be absorbed by plants. In the agricultural production, the soil available phosphorus content was used to guide the application of phosphate fertilizer. The available phosphorus content in soil is the main factor to determine the effect of phosphate fertilizer and its effect. Figure 1d showed the obvious difference of soil available phosphorus in different economic forest land. The content of soil available phosphorus in different economic forest land showed Camellia sinensis (24.33 g·kg^{-1}) > Cerasus yedoensis (22.60 g·kg^{-1}) > Phyllostachys heterocycla (19.04 g·kg^{-1}) > Myrica rubra (16.08 g·kg^{-1}) > Acer palmatum Thunb (15.88 g·kg^{-1}) > Grassland (14.56 g·kg^{-1}) > Cerasus pseudocerasus (13.95 g·kg^{-1}). The content of available phosphorus in soil was also different in different economic forest land. The available phosphorus content in Camellia sinensis land was 1.74 times that of soil available phosphorus in Cerasus pseudocerasus forest land. The content of soil available phosphorus in soil was mainly related to the amount of deciduous twigs. The release rate of phosphorus in soil was faster than that of the other nutrient element [12]. At the same time, the content of phosphorus in soil was also affected by fertilization and plant growth and absorption. High content of available phosphorus in the soil of economic forest land has an important influence on eutrophication, which is the main source of non-point source pollution. Therefore, in the control of non-point source pollution, the soil phosphorus output of economic forest land may be more worthy of attention.

3.5 Soil nutrients quality evaluation

According to the calculation of soil nutrient quality index (In table 3), The comprehensive index of soil nutrient quality in different economic forest lands varied between 1.541-2.250. The results of soil quality evaluation were "good" and "excellent", The average condition was "good" (average was 1.978). The average comprehensive index of soil nutrient quality from high to low was Cerasus yedoensis (2.144) > Phyllostachys heterocycla (2.021) > Cerasus pseudocerasus (1.974) > Acer palmatum Thunb (1.965) > Myrica rubra (1.952) > Camellia sinensis (1.896) > Grassland (1.822). It can be concluded from the analysis of the comprehensive index that the comprehensive status of soil nutrients in different economic forest lands in Yuyao is at the middle level, so it is necessary to improve the soil fertility. As can be seen from table 3, the quality of soil nutrients in economic forest land is generally limited by the content of available potassium. Among them, some Camellia sinensis land was very obvious.

Table 3. Soil quality index and comprehensive index of different economic forest land

Regions	Land use types	Soil organic matter	Soil total nitrogen	Soil available phosphorus	Soil available potassium	Soil nutrient quality index
Lianghui town	Camellia sinensis-1	3.000	3.000	3.000	1.333	1.541
	Camellia sinensis-2	3.000	3.000	3.000	3.000	2.250
	Phyllostachys heterocycla-1	3.000	3.000	2.802	2.269	1.898
	Phyllostachys heterocycla-2	3.000	3.000	2.720	2.170	1.846
	Phyllostachys heterocycla-3	3.000	3.000	2.883	2.749	2.122
	Phyllostachys heterocycla-4	3.000	3.000	3.000	2.933	2.219
Dalan town	Acer palmatum Thunb-1	3.000	3.000	2.781	3.000	2.148
	Acer palmatum Thunb-2	3.000	3.000	2.395	2.097	1.781
	Cerasus yedoensis-1	3.000	3.000	3.000	3.000	2.250
	Cerasus yedoensis-2	3.000	3.000	2.863	2.570	2.038
Mazhu towm	Cerasus pseudocerasus	3.000	3.000	2.395	3.000	1.974
	Grassland	3.000	3.000	2.456	2.177	1.822
	Myrica rubra-1	3.000	3.000	2.700	2.997	2.111
	Myrica rubra-2	3.000	3.000	2.374	3.000	1.965
Zhangting town	Myrica rubra-3	3.000	3.000	2.517	2.096	1.793
	Myrica rubra-4	3.000	3.000	2.578	2.149	1.822
	Myrica rubra-5	3.000	3.000	2.700	2.759	2.088
	Myrica rubra-6	3.000	3.000	2.781	2.352	1.932

4. Conclusion

There were significant differences in soil nutrient content in different economic forest land. The difference of soil organic matter content was the smallest between seven economic forest lands. The difference of soil available potassium and soil total nitrogen was larger. The soil nutrient status of Cerasus yedoensis forest land and Phyllostachys heterocycla forest land were better. Grassland and Camellia sinensis land soil nutrient was low. In addition, the soil nutrient status of Camellia sinensis land was greatly affected by available potassium.Through the comprehensive evaluation of the Nemero index method, The soil nutrient status of Cerasus yedoensis forest land and Phyllostachys heterocycla forest land belonged to the "excellent" level. The soil nutrient status of other economic forest lands belonged to the "good" level. In the study area, the soil nutrient status of the typical economic forest land was in the "good" level, and the soil nutrient quality was generally limited by the available potassium content.

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