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# Study on Land Use Mode and Soil Acidification Degree ——Take Heshan District of Yiyang City as an example

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**ABSTRACT:** Soil degradation has seriously threatened the red line of 1.8 billion mu of arable land in China, and soil acidification is an important part of soil degradation. Taking the typical red soil area of land use in the south as the research area, the influence of land use type on soil acidification. Soil acidification properties were determined by dense distribution points and sampling, and land use and red soil acidification characteristics were investigated and analyzed. Heshan District, Yiyang City, from the statistical analysis of soil acidification, the average pH value was 6.64, the standard deviation is, 0.84, the coefficient of variation was 12.59%; the mean EC value was 232.2  $\mu\text{s} / \text{cm}$ , the standard deviation is 191.7, the coefficient of variation was 82.54%, the overall pH of the soil is mainly weakly acidic, neutral and weakly alkaline, nearly 8% of the soil is acidic soil; From the spatial analysis of soil acidification, the acidified soil in Heshan District is mainly distributed in southeast China, the whole region is from the poles to the central region, from the northeast to the southeast, soil pH values showed a trend of gradually decreasing values. In the mountains of the northwest and the mountainous and hilly areas of the central south, the soil pH showed a gradually decreasing trend with the increasing elevation. The spatial distribution pattern of Soil EC values is similar to the pH values. This study shows that different land use methods have a profound influence on soil acidification. Among different land use methods in Heshan District, the pH value of forestry is the most obviously dispersed, followed by vegetable fields and farmland; Soil EC values in Heshan District are more concentrated than pH, among which the most obvious land use method is farmland, followed by vegetable fields and the mulberry garden. The causes of soil acidification under different land use methods include the following four aspects: first, long-term continuous cropping and agricultural harvest promote soil acidification; the second is unscientific soil testing and fertilizer formula. The following suggestions are put forward to alleviate the soil acidification problem: (1) the red soil area vigorously encourages farmers to return the straw to the field and pay attention to the combined use of lime. Not only for the legume straw, Also encourage returning to other crops, To maintain the acid-base balance in the soil and reduce the contribution of agricultural measures to soil acidification; (2) For the soil with a weak acid buffering capacity and a potential acidification trend, attention should be paid to the acidity balance adjustment management in the planting area, slow down the trend of continuous soil acidification; (3) Strengthen the urban atmospheric environment management, reducing the contribution of acid rain harm to soil acidification in agricultural areas; (4) Vigorously promote the integration construction of water and fertilizer, using the scientific soil testing formula, fertilization and fertilizer formula, increase the proportion of organic green fertilizer applied, reduce the dependence on chemical fertilizers, Reduce the aggravating effect of fertilization on soil acidification. Due to the relatively small soil sample data in this study and the test method is relatively simple, the reliability of the test data needs to be improved by following up more soil samples and more comprehensive test types. However, this paper still has some reference value for the influence laws and characteristics of different land use methods on soil acidification.

**KEYWORDS:** land use method; Heshan District; acidification; pH; EC; chemical fertilizer

## I. INTRODUCTION

With the rapid development of China's economy, long-term excessive development and extensive management of soil resources have led to serious soil degradation, such as soil erosion and secondary salinization in northwest China, black soil thinning, soil organic matter decline, and farmland acidification in southern China<sup>[1]</sup>. Studies show that in the past

20 years, in southern China, the red soil was rapidly acidified, and the soil pH decreased by 0.23-0.30 units<sup>[2]</sup>. The monitoring report of cultivated land quality released in 2017 also shows that the regional soil acidification problem in China is becoming increasingly obvious. For example, the soil in the middle reaches of the Yangtze River is generally strong acid ( $4.5 < \text{pH} < 5.5$ ) and moderate acid ( $5.5 < \text{pH} < 6.5$ ), and the two accounted for as high as 77%<sup>[3]</sup>. The severe situation of soil acidification has seriously threatened the production safety of grain and agricultural products in China, and it is also one of the major tests faced by the national implementation of the rural revitalization strategy. Soil acidification refers to the process in which the soil absorptive complex receives a certain amount of exchange hydrogen ions or aluminum ions to drain the alkaline salt-based ions in the soil. Soil acidification in natural process mainly refers to the large precipitation in the soil, while  $\text{H}^+$  and  $\text{Al}^{3+}$  increased process<sup>[4]</sup>. With the increasingly prominent influence of human activities on the soil acidification process, excessive chemical fertilizer application, planting of acid-causing crops, and unreasonable irrigation accelerate the acidification process of farmland soil and aggravate the degree of acidification different fertilization amount has different effects on soil acid, Wen Xing<sup>[5]</sup> pointed out that the large use of chemical fertilizer, especially the amount of acid fertilizer, calcium perphosphate, ammonium chloride and other acid fertilizer and compound fertilizer as the main raw material are easy to cause soil acidification. Different irrigation methods have different effects on soil acid characteristics, so Li Shuang<sup>[8]</sup> explored the influence of different irrigation methods on the acidification characteristics of soil in protected areas, it is found that drip irrigation is more conducive to inhibit soil acidification. Different planting crops also have different effects on soil acidification, Zhou Haiyan's<sup>[6]</sup> study of soil acidification in Qiyang County found that the acid production of three kinds of land use methods, including dry land, paddy field and forest land, was different, and the two main crop systems of oil crop and grain forest and economic forest, at the same time, Jigang<sup>[7]</sup> pointed out that abandonment can maintain soil pH. There are two main human factors affecting soil acidification: one is the increase of acid settlement due to air environmental pollution, and the other important factor is the improper land use method<sup>[9]</sup>. The focus of this paper is to explore the influence of different land use methods on soil acidification law and characteristics, and the typical red soil area Yiyang mountain district, for example, to explore the current situation of the degree of soil acidification analysis and cause analysis, can for the rational use of land in red soil area and ecological environment protection to provide scientific basis and reference.

## II. STUDY SITE OVERVIEW

Heshan District ( $112^{\circ}11' \sim 112^{\circ}43'$  E,  $28^{\circ}16' \sim 28^{\circ}53'$  N) is located in the north of central Hunan Province, on the western edge of Dongting Lake and Zijiang tail, with a total area of about 1279 km<sup>2</sup>. This region is a monsoon humid climate in the middle subtropical to the north subtropical transition, which is abundant in light and heat and abundant rainfall, with an annual average temperature of 16.9°C and an annual average precipitation of 1378.2 mm. The terrain of Heshan District is mainly plain, with complete mountains, hills and hills, with the characteristics of "one hill and two hills, five plains and two water towns". The terrain from southwest to northeast, in three steps, most of the ground elevation is below 100 m above sea level. There are quaternary red clay, slate, shale and lake phase sediments, and the soil pH ranges from 4.6 to 6.6. The soil types are mainly red soil and rice soil, and the tidal soil is also distributed in the lake area. The land use is mainly cultivated land, garden land and forest land, and the three land use methods account for 37%, 3.4% and 25% of the area respectively (Heshan District People's Government of Yiyang City, 2014). The main crops in the region are rice, tea, rape, corn, citrus, etc.

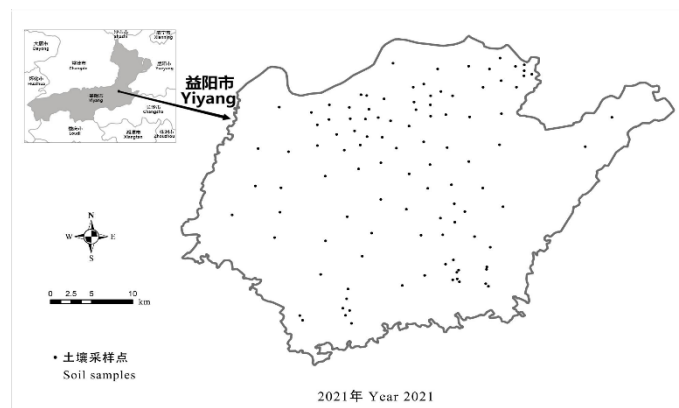


Figure 1. Geographical location and soil sampling point distribution map in Heshan District

### III. MATERIALS AND METHODS

#### 3.1 Soil sample collection and index determination

Samples were collected from July to August 2021. Three typical soil sections were collected 15~20cm from the soil surface, the soil samples were mixed in self-sealed bags, 121 soil samples of about 150g of each mass, and then brought back to the laboratory for pretreatment preparation, after removing non-soil parts and more than 2mm gravel, natural air drying, grinding and screening. Soil pH is determined by 1:5 soil volume mass ratio, portable pH meter (magnetic PHB-4, Shanghai Electrical Instrument Co. Ltd.); soil conductivity (EC) by 1:5 soil volume mass ratio, portable conductivity meter (DDB-303A, Shanghai Electrical Science Instrument Co, Ltd.).

#### 3.2 Research Methods

##### 3.2.1 Soil pH value classification

Soil pH value classification is conducted according to the unified classification standard of the second national soil census<sup>[10]</sup>. The pH value is divided from large to small (pH> 8.5), weak(7.5 <pH 7.5), weak (5.5 <pH 6.5) and acid (4.5 <pH 5.5). In this paper, all pH 5.5 soil are classified as acidified soil, which is strongly acidic (pH 4.5) and acidic (4.5 <pH 5.5)<sup>[11]</sup>.

##### 3.2.2 Characteristic analysis of soil acidification

The number and proportion of pH and EC values of each grade of soil sample points, Analyze the overall situation of soil acidification in Heshan District of Yiyang City and the soil acidification situation of different land use methods; The pH and EC value space interpolation treatments were performed using the Krigin interpolation method of the ArcGIS 10.8 software space analysis module, To obtain the spatial distribution map of soil pH values and EC values, The spatial distribution characteristics of pH values and EC values was analyzed; The experimental data were collated with Excel 2019, Boxplots of pH and EC values with Origin 2021, To analyze the dispersion of the data.

### IV. RESULTS AND ANALYSIS

#### 4.1 Analysis of soil acidification degree under different land use methods

##### 4.1.1 Statistical analysis of the soil acidification

The average pH of soil in Heshan District of Yiyang city was 6.64, the standard deviation was 0.84 and the coefficient of variation was 12.59%; the EC mean was 232.2  $\mu\text{s}/\text{cm}$ , the standard deviation was 191.7 and the coefficient of variation was 82.54%. Among the 121 soil samples collected, weakly acidic (5.5 <pH <6.5), neutral (6.5 <pH <7.5) and weakly alkaline (7.5 <pH <8.5) were 91.74% of total sites, strongly acidic (pH <4.5) and acidic (4.5 <pH <5.5) were 8.26% of total sites and no alkaline (pH >8.5). It shows that the soil pH of Heshan District in Yiyang city is mainly weakly acidic, neutral and weakly alkaline, and nearly 8% of the soil is acidic.

##### 4.1.2 Spatial analysis of soil acidification

Figure 1,2 shows the spatial distribution map of soil pH and EC value in Heshan District of Yiyang City. It can be seen that the acidified soil in Heshan District is mainly distributed in the southeast region, from the poles to the middle, and the soil pH value is gradually decreasing from northeast to southeast. In the mountains of the northwest and the mountainous and hilly areas of the central south, the soil pH showed a gradually decreasing trend with the increasing elevation. The spatial distribution pattern of soil EC value is similar to the pH value.

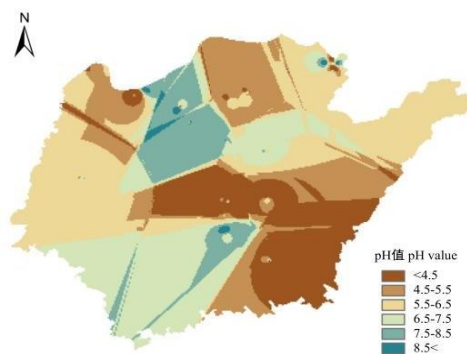


Fig.2 Spatial distribution of soil pH value in HeShan District

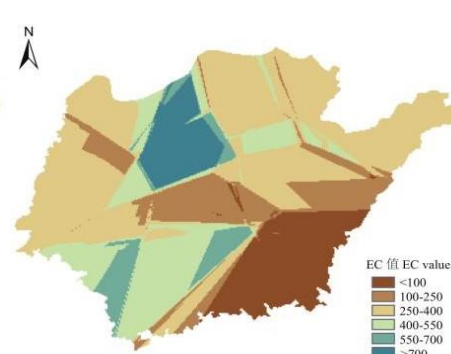


Fig.3 Spatial distribution of soil EC value in HeShan District

**4.2 Soil acidification characteristics of different land use methods**

Table 1 shows the soil acidification of different land utilization methods in Heshan District of Yiyang City. It can be seen that among the three main agricultural land types of cultivated land, garden land and forest land, the smallest average pH of cultivated land is 6.17; the second of garden land is 6.67; the largest average of woodland pH is 6.86. In cultivated land, the average pH of vegetable field is significantly higher than that of garden land, the average pH of tea garden is 5.47, and the largest is 6.79. According to the point statistics, the proportion of the smallest is 7.46%, the largest, 18.18%, in the second type, the largest, or 100.00%, the smallest, accounting for 10.00%. There is no acidification of two non-agricultural land in grassland and industrial land.

Graph 3, 4 For the dispersion of soil pH and EC values of different land use methods in Heshan District of Yiyang City, as it can be seen, among the different types of land use methods in Heshan District, the pH dispersion is most pronounced, next are the vegetable fields, the most concentrated distribution is in the farmland (since there is only one soil sample of the tea garden, one data is necessarily the most concentrated, but it is not representative, therefore, with the concentrated samples and better representative farmland as the most concentrated objects, the same is true for the EC values below); the soil EC values in Heshan District is more concentrated than pH, the most obvious and relatively dispersed land-use method is farmland, next are the vegetable fields, the most concentrated distribution is the mulberry garden.

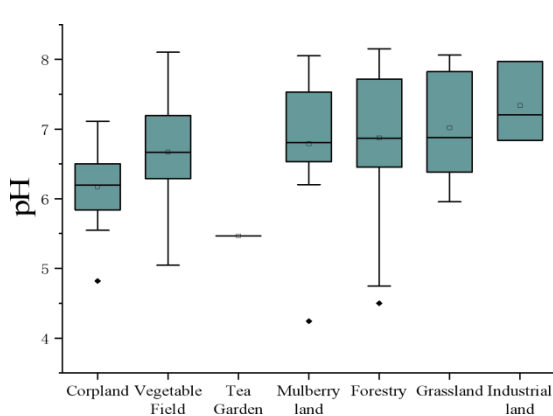


Fig.3 Box diagram of soil pH value in Heshan District

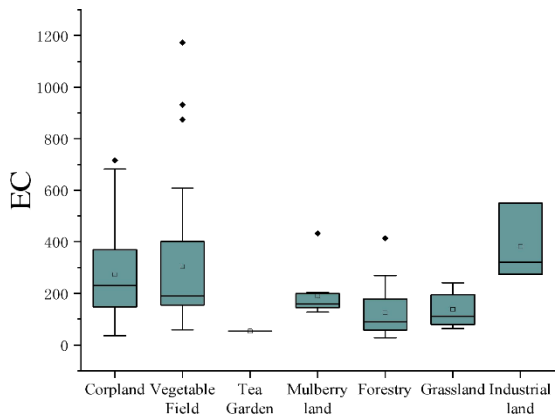


Fig.4 Box diagram of soil EC value in HeShan District

**Table 1 Soil acidification status of different land use methods in Heshan District**

Land use type	Point number	pH	CV%	Acidification points No.	Acidification ratio/%
corpland	31	6.17	7.61	1	3.23
Farmland	Vegetable Field	36	6.67	4	11.11
	Total	67	6.44	5	7.46
Tea Garden	1	5.47	100	1	100
Garden	Mulberry land	10	6.79	1	10
	Total	11	6.67	2	18.18
Forestry	27	6.86	13.77	3	11.11
Grassland	13	7.02	10.5	0	0
Industrial land	3	7.34	7.89	0	0

#### 4.3 Analysis of soil acidification under different land use methods

##### 4.3.1 Long-term continuous cropping and agricultural products harvest to promote soil acidification

Land use is the most important and direct activity of human intervention in the soil<sup>[12]</sup>. Long-term continuous planting of peanut, vegetable bean and other Gemini crops, will constantly absorb P, Fe, Zn and other elements in the soil, resulting in a decrease in the pH value of the plant root area, easy to cause soil acidification<sup>[13]</sup>. Zheng Jia<sup>[14]</sup>, pointed out that the lack of some elements, such as zinc, manganese, copper, resulting in the root amino acid secretion also prompted the rhizosphere soil acidification. Due to the predatory planting method of local farmers, the large area harvest of agricultural products will damage the soil-plant-atmosphere continuum (SPAC) water transport and the carbon and nitrogen cycle of the farmland ecosystem, so that the alkaline substances or base ions accumulated in the growth process of plants are greatly transported out of the soil, resulting in soil acidification.

##### 4.3.2 Acid rain deposition leads to soil acidification

Acid rain refers to the precipitation of pH below 5.6. Dongting Lake in Hunan Province is one of the most severely affected areas of acid rain in China<sup>[15]</sup>. Under rainy conditions, calcium, magnesium, potassium and other salt group ions in the soil dissolve down, hydrogen ions are adsorbed by the soil instead of salt group ions, and the soil gradually changes in the direction of acidic soil with unsaturated salt groups<sup>[16]</sup>. Soil acidification generally develops from topsoil to central soil and subsoil layer, and is positively correlated with acid rain concentration, quantity, and duration<sup>[17]</sup>. According to the ambient air quality in the central city of Yiyang City from January to December 2016 released by the People's Government of Yiyang City, the precipitation pH in 2016 is 5.1~7.6, the average monthly average pH value is less than 5.5, and the frequency of acid rain is 50% for 7 months<sup>[18]</sup>. The soil is eroded by acid rain, and acidic ions settle inside the soil, causing soil acidification.

##### 4.3.3 Do not pay attention to soil pH regulation to make soil continuous acidification

The acidity of the soil is determined by the chemical balance between acidic and alkaline substances. If there is too much acid into the soil, and the loss of alkaline material, the original balance of the soil will be destroyed, causing soil acidification<sup>[19]</sup>. Soil sample collection survey, found that local farmers will be a lot of corn, sorghum straw rot in the field and harvester left than artificial harvest rice relatively longer rice stubble in farmland, straw and stubble in the process of decomposition will produce a variety of organic acids, lead to soil acidification, thus poison the root system of crops. With the modern intensive agricultural production, farmers and agricultural cooperatives in pursuit of production, fertilizer, and some fertilizer is acid, mixed with water produce free acid, because the cooked lime is more expensive, and ignore the good performance of regulating acidity, making the cultivated land excess acid can not be timely neutralization, long make the soil continuous acidification. Liao Ping<sup>[20]</sup> found that lime had no significant effect on the soil organic matter and total nitrogen content; straw returning increased the soil organic matter content significantly without affecting the total nitrogen content. Therefore, straw returning to the field with lime can jointly achieve the increase of double cropping rice, soil acidification improvement and fertilizer cultivation. It also shows that it is advisable to apply lime on the acidic red soil double cropping rice field once every 4 years.

##### 4.3.4 Unscientific soil testing formula fertilization fertilizer formula intensifies the soil acidification of cultivated land

The proportion of farmers applying a large number of elements is unbalanced, the emphasis on nitrogen fertilizer is not balanced, and the phenomenon of light phosphorus and potassium fertilizer also exists. Unscientific soil testing formula fertilization fertilizer formula may lead to excessive application of a single element, reducing soil fertility, but also may lead to excessive application of acid fertilizer, exacerbating soil acidification. Fertilizer production enterprises "distribute fertilizer according to the square", fertilizer dealers "recommend fertilizer according to the square", farmers "buy fertilizer, apply fertilizer according to the square", achieve scientific fertilization, reduce the use of fertilizer, increase the proportion of green fertilizer to gradually alleviate soil acidification. In recent years, the planting area of green fertilizer in Heshan District has shown a decreasing trend, such as agricultural non-point source pollution, soil consolidation of rice paddy field and shallow tillage layer. However, in 2018, Heshan District has ensured the effective improvement of cultivated land fertility by vigorously promoting the production of green fertilizer, comprehensively implementing straw returning to the field technology and strengthening the management of fertilizer market. Promoting the integration of water and fertilizer can effectively improve the content of cultivated land and soil organic matter, vigorously promote the production of green fertilizer, comprehensively implement the straw returning technology, and strengthen the supervision of fertilizer market is an effective way to reduce agricultural non-point source pollution. Grasping the green fertilizer production, fertilizer supervision and market access from the source, and the integrated system of soil testing and formula fertilization technology promotes the bad situation of fertilizer selection and fertilization in our area, the concept of fertilization and fertilization structure has been continuously improved and optimized, and the acidification of soil acidification is improved year by year.

## V. CONCLUSION

This study shows that different land use methods have a profound influence on soil acidification: according to statistical analysis, among the three main pH of cultivated land, garden land and woodland, the average soil pH is 6.64, standard deviation is 0.84, the coefficient of variation is 12.59%, and soil acidity is mainly weakly acidic, neutral and alkaline. There is no acidification of two non-agricultural land in grassland and industrial land. From the perspective of spatial distribution, the acidified soil in Heshan District is mainly distributed in the southeast region, and the whole region gradually decreases the soil pH value from northeast to southeast.

The following suggestions are put forward to alleviate the soil acidification problem: (1) the red soil area vigorously encourages farmers to return the straw to the field and pay attention to the combined use of lime. Not only for legumes, but also for other crops, to maintain the acid-base balance of soil and reduce the contribution of agricultural measures to soil acidification<sup>[21]</sup>; (2) For soil with weak acid buffer capacity and potential acidification trend, attention should be paid to the management of pH balance in planting areas to slow down the trend of continuous soil acidification; (3) To strengthen urban atmospheric environment management, reduce the contribution of acid rain harm to soil acidification in agricultural areas; (4) Vigorously promote the integration of water and fertilizer, adopt scientific soil testing and fertilizer formula, increase the application proportion of organic green fertilizer, reduce the dependence on chemical fertilizer, and reduce the aggravating effect of fertilization on soil acidification. Due to the relatively small soil sample data in this study and the test method is relatively simple, the reliability of the test data needs to be improved by following up more soil samples and more comprehensive test types. However, this paper still has some reference value for the influence laws and characteristics of different land use methods on soil acidification.

## VI. ACKNOWLEDGEMENTS

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