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Planner-Oriented Soil Evaluation in China with TUSEC (Technique for Soil Evaluation and Categorization for Natural and Anthropogenic Soils)

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Key words: Soil evaluation, Soil function, TUSEC, Land use, China, Zhengzhou City

Abstract:

Purpose China is a fast developing country. In order to more rational use of soil resources, it is necessary to evaluate the functions of soils on the regional level, which can provide a reference to rational land-use planning.

Method In this paper, by using the method of TUSEC (Technique for Soil Evaluation and Categorization for Natural and Anthropogenic Soils), with some modifications of the parameters according to the local situation, the soil resource in suburb of Zhengzhou City in China has been evaluated for different functions.

Results The evaluation results show that the function of soil as component of water and nutrient cycles is in high levels while the function of wheat production is in the medium level in most of the area. Opposite to the function of transformation, the function of soils as filter and buffer for heavy metals in the southwest is relatively higher than the northeast.

Conclusions As urbanization is inevitable, the soil functions should be considered for a sustainable land use.

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1 Introduction

Soil is a complex and multi-functional body. In ecology, soil has functions as a filter, decomposing and recycling chemical and organic materials, as well as storing heat and water. It also provides habitat for plants and animals, including humans. Soil is important for human life by providing essential inputs like food and clean water. These aspects of multifunctionality of soil are also the basis of land use. However, human and environmental factors (such as land use change, fertilizer management, etc.) affect soil resources to a large extent at the same time. The encouragement of adapted soil use and soil protection became an object of land-use planning since soil is highly endangered by threats such as unadapted agricultural production, desertification and toxification. In order to protect soil resource, the functions of soils should be evaluated in the procedure of land use.

The Technique for Soil Evaluation and Categorisation for Natural and Anthropogenic Soils (TUSEC) (Lehmann et al. 2008) is a method for soil evaluation for natural and anthropogenically altered soils in the temperate zone. This method will be used and discussed in this study.

As a developing country, the progress of urbanization in China is speed up while the soil resources destroy intensively. In order to rational use of soil resources, it is necessary to evaluate functions of soils in China's regional area. The study of characteristic indicators and spatial variability of soil functions is undertaking in China now. This article brings the

methodology of TUSEC into China. Based on TUSEC, this study takes a city in the middle of China as the study area, and evaluates the functions of soil as storage, filtration and transformation medium and as site for wheat production. According to the evaluation results and considering present land-use situation, recommendations for reasonable land-use planning are given.

2 Materials and methods

2.1 Study area

Zhengzhou is a city in the middle of China, which located in the transition zone of low hills to fluvial plain, and the north boundary is to the Yellow River. The geographical coordinates is between 34 ° 36 '- 34 ° 57'N and 113 ° 27 '- 113 ° 51'E.

This area is in the climate zone of warm temperate and semi-humid continental monsoon. The annual average temperature is 14.2 ℃, and the annual evaporation is 1,508mm while the annual precipitation is 600-700mm. As to the average groundwater level, it's below 18.39 m.

2.3 Soil data

According to World Reference Base (WRB) for soil resources, the soils in the study area belong to Cambisols, Luvisols and Arenosols. Among them, Calcaric Cambisols and Calcaric-Fluvic Cambisols occupy almost 80% of all the whole area.

Calcaric Cambisols mainly distributes in loess hilly area and sloping plain in the southwest, which is a zonal soil formed by the climate condition of warm temperate monsoon and soil parent materials are mostly proluvial and alluvial with a rich content of lime. Calcaric-Fluvic Cambisols mainly distributes in the fluvial plain in the northeast, which developed from the fluvial materials and formed by groundwater and cultivation.

This study uses the local soil type as evaluation unit, and uses data from "Notes of Native soil types in Henan Province". The basic soil parameters are showing in tab. 1 and the distribution of soil types is showing in fig. 1.

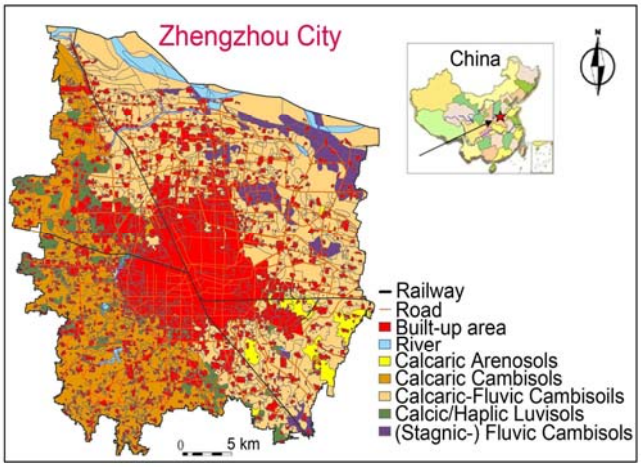

Fig.1 Location and soil map of Zhengzhou City

Tab.1 The basic soil parameters of Zhengzhou City

Soil type / **Property**	Calcaric Arenosols	Calcaric Cambisols	Calcaric-Fluvic Cambisols	Calcic/Haplic Luvisols	(Stagnic-) Fluvic Cambisols
depth of topsoil [cm]	8	70	20	70-90	20-30
OMC of topsoil [%]	0.56	0.76-1.14	0.24-1.01	0.76-1.25	0.9-1.31
pH	8.2-8.3	8.2-8.4	8.1-8.9	8.2-8.4	8.3-8.4
bulk density	1.38-1.40	1.25-1.50	1.28-1.41	1.29-1.50	1.19-1.38
texture	S	SL-CL	S-CL	SL-CL	CL-SiC
structure	sub blocky-single grain	(sub) blocky	granular - blocky	(sub) granular - (sub) blocky	grain - sub blocky
coarse material [%vol]	0	0-22	0	0-5	0

2.2 Methodology

TUSEC is an approach for the schematic assessment of soil functions. In this paper, we focus on soil as component of the water cycle and the nutrient cycle; as filter and buffer for heavy metals; as transformation medium; and as site for wheat production.

First of all, the data and information which used for evaluation were collected, including the data of soil profiles, soil map and land-use maps.

The basic information of soil profiles includes: thickness of horizons, organic matter content (OMC), pH-value, bulk density, soil texture, soil structure, content of coarse material, potential rooting depth. The parameters which can be estimated according to appendixes: clay content, available field capacity (aFC), air capacity (AC), effective cation exchange capacity (CEC), saturated hydraulic conductivity (kf-value). Some background value can be referenced by maps, such as origin of substrate, groundwater level, and slope gradient.

Secondly, based on the soil map of suburb area of Zhengzhou City in 2002 (1:50,000), this practice uses the local soil type as evaluation unit to evaluate different soil functions by the method introduced in the book of TUSEC. The levels from 1 to 5 represent capabilities of soil functions from “very high” to “very low”. Then come out the draft results. With the draft results, we can verify whether the criteria proper or not. Do modifications until the results are consistent with the actual situation. Using the software of ArcGIS, the final results were displayed in maps.

Finally, according to the results and comparing with the land-use situation, some suggestions to land-use planning were given.

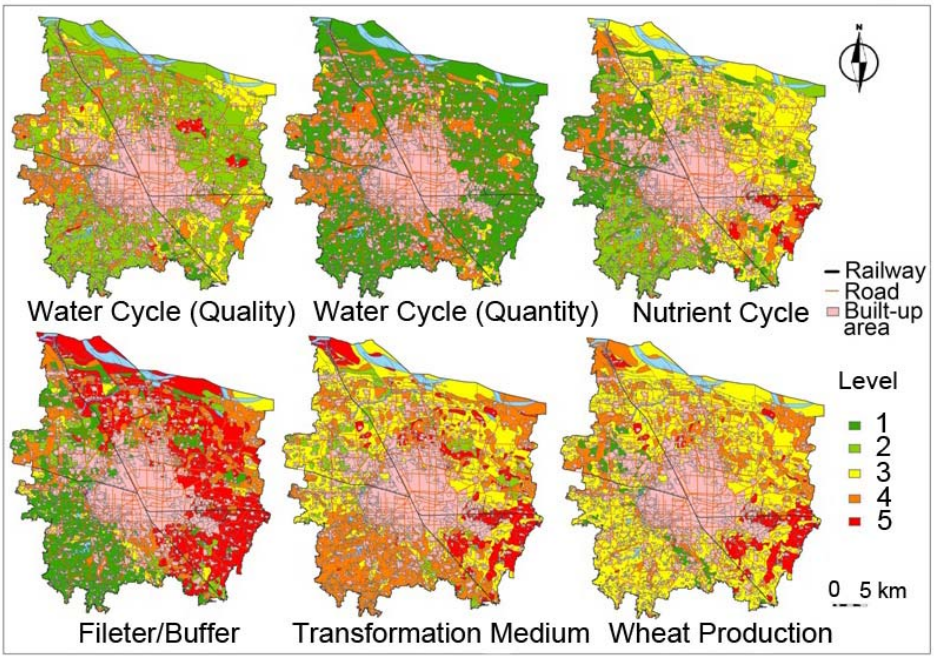

Fig. 2 Results of evaluation

3 Results of evaluation

In this study, the software of ArcGIS is used to realize visualization of evaluation results. The function of soil as component of water and nutrient cycles is in high levels while the function of wheat production is in the medium level in most of the area. Opposite to the function of transformation, the function of soils as filter and buffer for heavy metals in the southwest is relatively higher than the northeast. The results of evaluation are showing in fig. 2. The maps of results are based on soil map and land-use map. There are five levels for each function which show in different colors: from green to red represents high to low.

4 Conclusions and discussions

This study put the method of TUSEC into practice and considered how to use

the results for spatial planning. The practice shows that the method of TUSEC can be used in China by some modifications of criteria according to the local actual situation. Combined with the land utilization, the results of evaluation can be used to guide local land-use planning.

From the practice of TUSEC application in China, we can draw the following conclusions:

1) The grafting of a method requires adjustments according to local situations. TUSEC is designed for central European area, so it needs modifications when it is applied to China according to actual conditions. 2) Expressing the evaluation results by maps gives a clear visual overview in mind. The images can give a better understand of soil functions to the observers. 3) The evaluation results provide references to land-use planning. On the basis of the results, different aspects can be guided, such as urban development, food production, and ecological protection. Taking Zhengzhou City as an example, according to the evaluation results of soil functions, we can get the following suggestions: the crop development should be supplied with sufficient water and nutrient in the southwest; the vegetation cover should be strengthened in the southeast; and factories and facilities which may introduce pollution should be avoided in the east.

This paper is an initial attempt of TUSEC method using in China, and there are also some problems in this study and some improvements can be done in the future:

1) More soil functions can be evaluated. Not only functions mentioned above, soil also has the functions as habitat basis for life, natural and cultural historical archive, etc. 2) The modifications of parameters are limited to the study area, and the selection of parameters can be considered more. If we want to use TUSEC in other regions of China, the adjustments are also needed based on their realities. 3) There are many factors should be considered in the practical land-use planning, and soil is only one of the factors. Although soil resource is not the biggest limitation factor in the urban development, it will be a win-win situation if soil conservation and urban planning can be combined.

Evaluation of soil functions allows people to have a comprehensive understanding of soils and provides references to land-use planning. Given a certain amount of space for soils, they can provide habitat for plants and animals, sustain water nutrient cycling, and reduce pollution by filtration and buffering for heavy metals. All of these will form a sustainable development of urbanization. All in all, the evaluation of soil functions has great significance to China.

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Thank

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