The spatial distribution of soil nutrients matter and variation characteristics of Datong Abandoned Coal Mine area in Huainan City

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Abstract. This paper describes the analysis of nutrients matter in soil sampled from Datong abandoned mining area in Huainan City. Spatial interpolation in GIS is applied to the revelation of spatial distribution of nutrients matter. Results show that: In abandoned land in Datong coal mining, the level of available phosphorus in soil was very short and the following grades, and the level of nitrogen was short grades, and the level of organic matter was medium and the following grades. Distribution of these heavy metals present a stronger spatial relevance because their spatial pattern are mainly influenced by natural factors such as complex micro-geomorphology, vegetation, topography, strongly human disturbance and other structural factors. All of spatial variability was middle and small scale. Characteristic of spatial variation was relation with the complex distribution object. Random factors, such as sampling interval, soil type and so on, play a relatively greater role in spatial variability of nutrients matter.

1. Introduction
In recent years, serious ecological environment problems produced by the mineral resources exploitation has been aroused people's wide attention, and the research was gradually strengthened to control and recovery the ecological environment of abandoned coal mine. Since the 1990s, the ecological restoration research in our country has been made more progresses [1]. Method of combining GIS on geo-statistics for analysis spatial distribution of nutrients and its variation in soil is one of the most effective ways, and this method is helpful to reveal the spatial distribution characteristics of soil nutrient and its process of ecological restoration function. GIS spatial interpolation and geo-statistical methods was applied by scholars at home and abroad of to analyze soil nutrient, texture in tobacco field, organic matter and available potassium spatial variation characteristics in farmland but little research of abandoned coal mine lands [2-3]. Preciously existing use of plant community succession and configuring measures for ecological restoration of Datong abandoned coal mine lands in Huainan City, but specific diagnosis of soil environmental status and fertility was lack, especially aspect of soil pollution, fertility, nutrient about spatial distribution and variation characteristics in-depth studies, and ecological restoration and environment regulation was lack of targeted and inefficiency of recovery. In this study, on the basis of regional soil nutrient survey, using GIS technology, nutrients spatial...
distribution and variation characteristics was analyzed, to reveal the problem of soil nutrients and influencing factors existing in the abandoned mine, to provide a scientific basis for the effective restoration of abandoned lands of mines.

2. Situation of the study area
   Datong mine in Huainan City was built in 1903, and minor mine shut down in 2007. After mine shut down, the subsidence area was repaired, and the wetland park for ecological tourism was gradually opening. After main mine shutting down in 1978. Datong wetland was transformed in coal mining subsidence after modification, repair, including the disused coal gangue dumps (slopes), waste motor-pumped wells, filter of abandoned chemical plant, waste water well, and area is only about 4.38 km². After the ecological restoration, Datong abandoned mine was preliminary built into Living environment. Compared with similar area, there was the gap of the urban environmental construction and effect of ecological restoration goal in Datong area, and exists problems such as the poor environment quality of soil and water, vegetation looks like the bad.

3. Sources of data, processing and the research methods
   42 soil sampling points were selected (figure 1), and sampled the soil in depth of 0 ~ 10 cm. Air-dry after mixing, and grinding with agate mortar then sieving by 200 mesh nylon. The content of ammonia nitrogen, available phosphorus, organic matter in soil were respectively detected by NaCl leaching-ultraviolet spectrometry, molybdenum antimony colorimetric method, potassium dichromate volumetric method. With ArcGIS10.0 software, the sample point area registration with topographic map, using GPS positioning, and using ordinary kriging spatial interpolation method, the content spatial distribution of heavy metal element and ammonium nitrogen, effective phosphorus and organic matter, respectively, were get, and soil nutrients of semi-variance function theory model and parameters were fitted by GS + 7.0 software in the studied area.

Figure 1. Study area and distribution of sample locations
4. Results and analysis

4.1 Spatial distribution of soil nutrient content

From the content of ammonium nitrogen, available phosphorus and soil organic matter, three kinds of nutrients in the soil of abandoned lands were lack, only the organic matter in the forest and surrounding area were abundant. Three kinds of nutrient content were low value area in coal gangue heap, abandoned coal mine area and subsidence area, and the distribution trend of nutrient matter content were reduced from center to outer-ring (figure 2).

![Spatial distribution of nutritive materials in the soil with the depth of 0-10cm](image)

**Figure 2.** Spatial distribution of nutritive materials in the soil with the depth of 0-10cm

4.2 Spatial variation characteristics of the soil nutrients

By fitting the semi-variance function curve of the soil ammonium nitrogen, available phosphorus and organic matter, optimal theoretical models and parameters was get (table 1). Nugget (C₀) constant was error caused by detecting and caused by the stochastic variations of sampling to choose the discontinuity scale. C₁ + C₀ was the sum of structural variation and random variation [4]. The ratio between nugget constant and base stations value was spatial variation random factors accounted for the proportion of the total variation, such as the ratio less than 0.25 illustrating nutrients spatial correlation was significant, and structural variation dominated, and random variation was small. Three nutrients of ratio between nugget constant and base stations values were all less than 0.129, showed that the soil nutrients of structural variation was larger, i.e. that the soil nutrients was influenced significantly by the natural factors such as the micro-topography, parent material in soil and vegetation and other, and micro-relief complex caused by abandoned coal gangue heap and subsidence, and diverse vegetation types were the dominant factors influencing the spatial variation. Available phosphorus of ratio between nugget constant and base stations values was 0.129, and the value was large relatively, and its variation mainly affected by random factors (such as coal gangue, chemical plant wastewater). Variation was spatial variation scale size, and spatial variability of soil nutrients scale range was 2.079 ~ 2.079 m. The variation of available phosphorus scale was relatively larger, and the scale was similar with the coal gangue heap, or the subsidence, but spatial variability of ammonium nitrogen and organic matter was small scale, which was related to scale of micro-geomorphology such as abandoned mine, chemical waste water wells, filter pool in the study area, also was closely related to the complex of interference caused by land use type affected the spatial distribution of nutrients.
Table 1. Spatial variation parameters of nutritive materials in soils of abandoned coal mine

| Factor                | Theoretical model | Piece of gold/C₀ | Base stations values/C₀+C₁ | C₀/C₀+C₁ Variation | Decision coefficient/R² | Residual/RSS |
|-----------------------|-------------------|------------------|-----------------------------|---------------------|--------------------------|--------------|
| Ammonium nitrogen     | Exponential model | 165              | 2495                        | 0.066               | 2.079                    | 0.857        | 3.6×10⁻¹    |
| Rapid available phosphorus | Gaussian model   | 24200            | 187800                      | 0.129               | 117,779                  | 0.839        | 4.42×10⁻³   |
| Organic matter        | Gaussian model    | 0.001            | 1.544                       | 0.001               | 28.752                   | 0.946        | 1.81×10⁻¹   |

The function curve of soil nutrients content variation was shown in figure 3. The fitting curve of exponential model function for ammonium nitrogen was suitable, but the fitting curve of Gaussian model function for available phosphorus and organic matter were suitable. The determination coefficient (R²) was the fitting accuracy, the greater the R² said the better fitting effect. The fitting precision for soil nutrients content variation was greater than 0.839, and the function model simulation had achieved high accuracy, which was good simulation effect. Within the scope of the variation, ratio between nugget constant and base stations was below 25%, and the soil nutrients spatial correlation was significant, which was effected significantly by human interference factors such as the coal gangue, subsidence area and chemical plant wastewater, and sampling spacing and soil type was less affected.

Figure 3. Fitted semi-variance model of nutritive materials in soils

5. Conclusion

The average content of ammonium nitrogen and available phosphorus in soil was lack and very lack grades respectively. The average content of soil organic matter was the medium level, the area proportion of the medium grade in Datong abandoned coal mining. Overall, the soil nutrients in coal mine soil was lack, mainly distributed in coal gangue heap, abandoned coal mine and subsidence areas, both reduced from center to the surrounding. The structural variation of nutrients spatial distribution change was dominated in the Datong coal mine soil, and the effect factors such as region of complex landform and vegetation was remarkable. The spatial variation scale of available phosphorus was similar to size of coal gangue heap, subsidence, but spatial variation scale of ammonium nitrogen and organic matter were small. Spatial autocorrelation of soil nutrients was significant, affecting by the complex terrain of abandoned lands (abandoned coal mine, waste water wells and filter) and strong anthropogenic interference significantly, on the contrary, the influence of the random variable factors such as the sampling interval and soil type was little.
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