Characteristics and source of soil selenium content in Zhangba Village, Lintong District, Shaanxi Province

Xinxing Qiao, Huawei Ji\(^1\), Jijun Zhang, Aorui Li, Rui Ren, Xu Chao and Kui Hu

Shaanxi Center of Hydrogeological, Engineering and Environment Geological survey, Xi’an, China

\(^1\)Email: dbxxqz@163.com

Abstract. Soil selenium content affects the absorption and accumulation of selenium in crops and ultimately affects human health; therefore, it is of great significance to study the characteristics of selenium content in soils and crops. Based on the previous agricultural geological survey and research carried out in Lintong area, and combined with data of Second National Land Survey, the agricultural geological survey and evaluation at the village level was carried out in Zhangba Village, Lintong District. Distribution characteristics of soil selenium content in each plot and selenium levels in crops were analyzed systemically, and the causes and influence factors of soil selenium was preliminarily studied. This survey found that selenium content of the soils and crops in Zhangba Village all met the standard of selenium enrichment. This finding provides strong support for land resource planning and management and rational utilization of selenium-rich soil resources in this area, moreover, it is of great significance to adjust planting structure, improve land use value, and promote development of selenium-rich agriculture.

1. Introduction

As an essential trace element, selenium has attracted much attention for its ability to promote animal immune function, stimulate the production of proteins and antibodies, as well as its special anti-oxidation, anti-cancer and detoxification. Moreover, selenium supplement scientifically can prevent many diseases such as high blood pressure and Keshan disease [1-3]. With people’s understanding of selenium, selenium-enriched agricultural products are gradually selling well, greatly increasing the added value of agricultural products [4-7]. Researches show that selenium in plants mainly comes from the soil and then enters the human body through the food chain, and thus soil selenium content affects the absorption and accumulation of selenium in crops and ultimately affects human health [2]. Therefore, it is of great significance to study soil environments, characteristics of selenium content in soils and crops, and causes of soil selenium content. This study is based on the work of Provincial Public Welfare Projects "Geochemical survey and evaluation of selenium-rich area in Guanzhong-Tianshui Economic Zone (Guanzhong Basin)" and "Construction of demonstration base for planting Selenium-rich crops in Shaanxi Province" implemented by the Shaanxi Institute of Geological Survey. In this study, soil and crop samples at the village level were systematically collected and analyzed in Zhangba Village, Lintong District, the distribution of selenium-rich soil and selenium-rich crops in the area was ascertained, and the cause of soil selenium was preliminary studied. It is expected to provide a theoretical basis for the development and utilization of selenium-rich resources, planting structure adjustment and the development of selenium-rich industries.
2. Research method and design

2.1. Overview of the research area
The study area is located in the hinterland of Guanzhong Plain, Jingwei Alluvial Plain, and the northwest of Lintong District. The administrative division belongs to Xiangqiao Street Office, Lintong District, Xi'an. The landform type is river terraces, the water system in the area is developed, the Wei River passes through the border, and the groundwater resources are abundant, suitable for crop growth. The soil type is Lou soil, which belongs to the main subtype of cinnamon soil. It has a high degree of maturation, is loose and easy to cultivate, has a long suitable tillage time, has good water and fertilizer retention capacity, rich minerals in the soil, and high fertility. It is a high-quality soil suitable for agricultural development [8]. The land use in the area is relatively simple, mainly agricultural land, and the agricultural planting is mostly wheat, corn, vegetables, etc. The study area has a warm temperate continental monsoon climate with four distinct seasons, a mild climate, and convenient transportation in the area, which provides favourable conditions for the development and utilization of selenium-rich soil resources.

2.2. Sample collection
Based on the results of county agricultural geological surveys and evaluations completed in the past, a 1:5,000 village group-level agricultural geological survey and evaluation was carried out. The survey evaluated an area of 3.26 km². A total of 210 surface soil samples (0-20 cm) and 24 crop samples were collected. The sampling method is in accordance with the "Land Quality Geochemical Survey and Evaluation" specifications. According to the existing planting structure of crops, bulk crops are selected for collection in a targeted manner. Among them, 5 pieces of celery, 8 pieces of wheat and 11 pieces of corn.

2.3. Sample treatment and analysis test
The soil sample was naturally air-dried, crushed the agglomerates with wooden sticks, passed through a 20-mesh nylon sieve, and extracted 500 g and sent to the laboratory for analysis. Plant samples were washed and dried, the non-edible parts were removed, chopped or smashed with a tissue masher. An appropriate amount of the sample was weighed, soaked in nitric acid overnight, and then hydrogen peroxide was added, the inner lid and the outer cover were covered and tighten, and then placed in microwave. After 3-4 hours of digestion in the instrument and then cooling, the solution was transferred and diluted to a certain volume for analysis. Se content was analyzed by ICP-MS, and soil pH was analyzed by pH meter.

The sample analysis and testing were undertaken by the Xi'an Mineral Resources Supervision and Testing Center of the Ministry of Land and Resources, and the analysis quality and requirements were implemented in accordance with the "Land Quality Geochemical Survey and Evaluation". During the test, four national first-level standards (GBW07423, GBW07430, GBW07446, GBW07429) were randomly added to control the quality of analysis. The reporting rate of all samples was 100%, and the accuracy and precision monitoring sample qualification rate was over 98%.

2.4. Data processing
Use MAPGIS software to process the data, respectively count the number of samples (N), arithmetic mean (X), standard deviation (S), coefficient of variation (Cv) and gradually eliminate the mean plus or minus 2 times the standard deviation Arithmetic mean (Xo), geometric mean (Xg), median (Me) and maximum (Max) and minimum (Min). Data evaluation is the use of ArcGIS software and land quality geochemical survey and evaluation software to assign the analysis data to the two-tone map. According to the "Land Quality Geochemical Survey and Evaluation" specification, the relevant evaluation and classification index are calculated, and single element evaluation and synthesis are performed.
3. Results

3.1. Soil selenium evaluation
With reference to the lower limit of the soil selenium-enriched standard of 0.2 mg/kg in the Guanzhong area of Shaanxi Province [9-10], the selenium content in the plot of Zhangba Village is rich, and there are as many as 107 selenium-rich soil plots in the village (Table 1), occupying a plot 98.17% of the total, of which 81 plots with a soil selenium content of more than 0.4 mg/kg, accounting for 74.31% of the entire district, distributed throughout the village; and 17 plots with a soil selenium content of 0.3~0.4 mg/kg, accounting for 15.60% of the whole district is mainly distributed in the east and south of the village; there are 9 plots with soil selenium content of 0.2~0.3 mg/kg, accounting for 8.26% of the whole district. There are 2 low-selenium (Se ≤ 0.2 mg/kg) plots, accounting for only 1.83% of the total [11].

| Element | Selenium-rich | Selenium-poor |
|---------|---------------|---------------|
|         | > 0.4          | 0.3 < Se ≤ 0.4 | 0.2 < Se ≤ 0.3 | ≤ 0.2 |
| No.     | Proportion (%) | No.           | Proportion (%) | No.   | Proportion (%) | No.   | Proportion (%) |
| Se      | 81            | 74.31         | 17            | 15.60 | 9            | 8.26  | 2            | 1.83 |

3.2. Comprehensive evaluation of soil environmental geochemistry
This soil environmental quality assessment is based on the "Soil Environmental Quality Standards", and the corresponding grading standard values are selected according to the specific pH conditions. Based on the single index soil environmental geochemical grade classification, the comprehensive soil environmental geochemical grade of each evaluation unit is equivalent to the worst grade of the environmental grade divided by a single indicator, from which the comprehensive evaluation results of the soil environmental quality in the study area are calculated. The comprehensive evaluation results of soil environment and geochemistry in Zhangba Village plot (Table 2) show that the soil environment of the plot in Zhangba Village is clean, with clean soil and pollution-free plots.

| Comprehensive grade | First class | Second class | Third class | Fourth class | Fifth class |
|---------------------|-------------|--------------|-------------|--------------|-------------|
| No. Proportion (%)  | No. Proportion (%) | No. Proportion (%) | No. Proportion (%) | No. Proportion (%) |
| Soil environmental quality | 109         | 100          | 0           | 0            | 0           | 0            | 0            | 0            |

3.3. Comprehensive geochemical evaluation of soil quality
The comprehensive geochemical evaluation results of the soil quality of the Zhangba village plot (Table 3) show that the soil quality of the plot of the village is generally good, accounting for 87.16% of the total number of plots, distributed throughout the region; followed by high-quality land, occupying the total number of plots 8.26% of the land is mainly distributed in Nanjia Village-Xiliu Village and the northern part of Zhangba; medium-sized areas are scattered in the south of Dongba Village and Nanjia Village, occupying 4.59% of the total land; there is no difference and inferior land.
Table 3. Comprehensive grade statistics of soil quality and geochemistry of Zhangba Village plot

| Comprehensive grade | First class | Second class | Third class | Fourth class | Fifth class |
|---------------------|-------------|--------------|-------------|--------------|------------|
| No. proportion (%)  | 9 8.26      | 95 87.16     | 5 4.59      | 0 0          | 0 0        |

3.4. Selenium content of crops

A total of 24 crop samples were collected in the village, and the selenium enrichment rate reached 83% (the selenium enrichment standard refers to the Chinese food industry standard HB001/T-2013, bulk crop Se ≥ 0.02 mg/kg, vegetable Se ≥ 0.01 mg/kg). Among them, 5 pieces of celery, selenium content 0.007~0.146 mg/kg; 8 pieces of wheat, selenium content 0.052~1.025 mg/kg; 11 pieces of corn, selenium content 0.015~0.271 mg/kg.

To sum up, the soil of Zhangba Village plot in Lintong District is rich in selenium, and most plots contain more than 0.4 mg/kg of selenium. The soil environment is clean, and the comprehensive grade of land quality and geochemistry is generally excellent. High, with basic soil conditions for the development of selenium-rich agricultural products.

4. Discussions

The causes of selenium-rich soil can be divided into two types: natural causes and man-made causes [12]. The study area is located in the alluvial-diluvial zone in the piedmont of the northern piedmont of the Qinling Mountains. According to the previous surface soil and "T" profile survey results, it is believed that the selenium-rich soil is generally distributed in the alluvial zone. The soil is piedmont alluvium and the composition is sand. Clay and clay layer, the lower part is gravel layer. The soil profile shows that the selenium content of the surface soil is higher than that of the deep soil, indicating that the soil selenium does not have the conditions of high background content of geological origin. Human activities played an important role after natural soil formation [9, 13].

The surface water in the study area is underdeveloped, and the groundwater survey shows that it contains selenium. Field irrigation is well irrigation. Part of the selenium is carried during irrigation and gradually replenishes the soil. This is one of the main ways of soil selenium input [14]. Irrigation water for shallow water is calculated based on 90 tons of water per mu, and the average cumulative input of selenium is 3.087 g/mu, as shown in Table 4.

Table 4. Statistics of selenium content in irrigation water of Zhangba Village plot

| Sample serial | GGS-1 | GGS-2 | GGS-3 | GGS-4 | GGS-5 | GGS-6 | GGS-7 | GGS-8 |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Se/mg·L⁻¹     | 0.037 | 0.037 | 0.036 | 0.029 | 0.036 | 0.034 | 0.031 | 0.0553 |
| average value |       |       |       | 0.0343|       |       |       |       |
| g/mu 90 tons of|       |       |       | 3.087 |       |       |       |       |

The work area is located between Yanliang and Weinan. Yanliang is a national-level comprehensive aviation industrial base integrating design, manufacturing and flight testing in China. It has Yanliang Aviation Manufacturing Park and a large number of heavy-duty enterprises. Selenium is widely used in high-tech fields such as high-performance batteries, integrated circuits, superconducting materials, optical fibers and semiconductor materials, special glass, steel, and rubber industries. Therefore, industrial waste gas and wastewater in the region contain a certain amount of selenium. Studies have pointed out that the largest external factors affecting the selenium content in the soil are dry and wet deposition, irrigation and fertilizers, while the impact of atmospheric deposition accounts for as much as 89%. Therefore, the selenium content in the work area may be related to atmospheric deposition [15-17].
The work area is mainly covered by farming, with uninterrupted production in two seasons a year. Investigations have shown that a large number of plant roots, stems and leaves contain sufficient selenium, which returns to the soil with the fall of plants, which is also one of the ways of soil selenium enrichment. At the same time, human activities and agricultural fertilization have also increased the source of soil selenium [18-19].

5. Conclusions
The survey found that Zhangba Village, Lintong District, has clean soil environment, good overall land quality and geochemical comprehensive grade, rich selenium content in the soil, high selenium enrichment rate of crops, and basic soil conditions for the development of selenium-enriched agricultural products. Resource planning and management and the rational utilization of selenium-rich soil resources provide strong support, which is of great significance to enhance the value of land use and promote the development of selenium-rich agriculture.

In addition, the cause of selenium-enriched surface soil in the study area is closely related to atmospheric dry and wet sedimentation and groundwater irrigation. Secondly, agricultural production processes such as returning selenium-enriched crops to the field are also important ways of soil selenium input. Human activities and agricultural fertilization have also increased to varying degrees the source of soil selenium.

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