Distribution and transfer of Se in soil of Hainan Province

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Abstract. Soil plays an important role to human health. Selenium is an essential nutrient for health. Se in soil will affect human health mainly by transferring to rice and other crops, and then to human body through the food chain .So it's necessary to analyse distribution of Se concentration in soil and its bioaccumulation ability from soil to rice. In this study, concentrations of soil Se ranged from 108.41-618.23μg/kg by counties. The average value was 343.90μg/kg, which was higher than soil background. It indicated that soil in Hainan was loaded with selenium. Soil in northeast contains more Se than that in southwest and Se content in natural soil was significant higher than cultivated soil. Positive correlations were seen between soil Se, rice Se and C/100,000. The transfer ability of Se varies in counties.

1.Introduction

As the material basis which biology relies on to survive, soil plays a nonnegligible role to human health. Soil affects water quality, plants, the atmosphere, and further human health through the food chain [1]. Studies have shown distribution similarities between longevity index and some elements in soil like Se and Zn in China [2], demonstrating that longevity has correlation with soil environment [3].

Selenium is an essential nutrient, and adequate amounts are required for optimal health [4]. It acts as a potent antioxidant protecting cells from oxygen free radicals and thus can slow the aging process [5-6]. Moreover, adequate concentrations of Se might increase the lifespan of centenarians, which are a representative group for healthy aging [7]. Se in soil can affect health mainly by transferring to rice and other crops, and then to human body through the food chain. So it's necessary to analyse distribution of Se concentration in soil and its bioaccumulation ability from soil to rice.

Hainan Province is an island famous for its longevity and was recognized by the International Expert Committee on Population Aging and Longevity as a "World Longevity Island" on August 27, 2014 [8-9]. . According to the demographic database of the sixth Chinese census, there are 1162

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centenarians in Hainan Island and their prevalence per 100,000 people (C/100,000) is 18.75 (China NBS), with both values ranking highest in China (Fig. 1) [7]. It's worth investigating Se concentration and its potential effect on longevity of Hainan

This paper analyzed distribution of Se in soil of Hainan Province. The bioaccumulation factor, as well as relationships between soil Se, rice Se and longevity index were also discussed. It will help provide data support and theoretical basis for identify contribution of Se (especially soil Se) to human health.

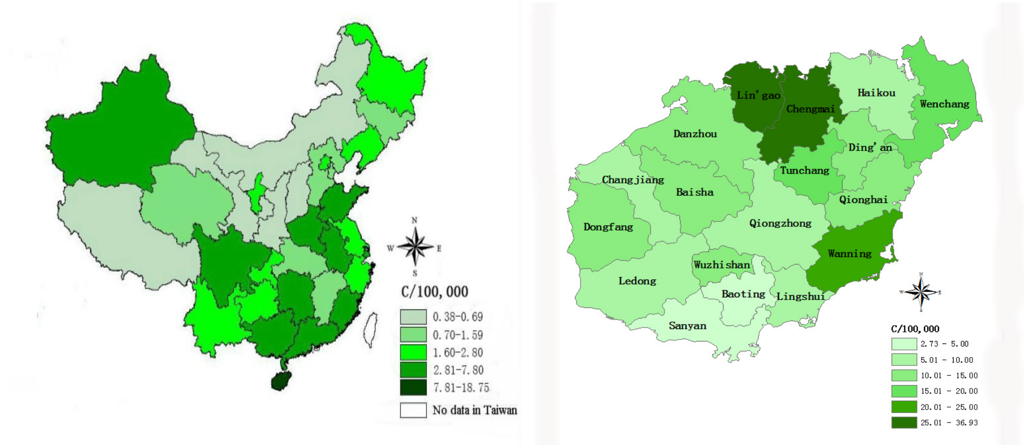


Figure 1. Distribution of centenarians per 100,000 people in China and Hainan Island

2.Materials and method

2.1 Study area

Hainan is a province at the southern tip of China with an area of 35,100 km^2, a latitude of 18˚10′ to 20˚10′ North and a longitude from 108˚37′ to 111˚05′ East. The climate is tropical monsoon with an average annual rainfall of 1600–2500 mm and average annual temperature of 23–25°C [10].

2.2 Sample collection and analytical methods

Population data were collected from the Chinese demographic database of the sixth census [11]. Samples of rice were also collected and the analytical methods and results had already been published [9].

Samples of natural and cultivated soil were collected from all 18 counties in Hainan Province. They were sealed in plastic bags and immediately transported to the laboratory. After grinding, sieving and drying, approximately 0.0500 g soil from each sample was placed in a 50 mL beaker and digested with 4 mL concentrated nitric acid and 1 ml concentrated perchloric acid. Samples were then carefully evaporated to near dryness on an electric heating plate at 100 -120°C until the soil turned grayish white. Then 2 ml of concentrated hydrochloric acid was added for reduction .The residue was transferred to a 10 mL polyethylene bottle and diluted to the volume for later analysis. Se concentration was determined by hydride generation atomic fluorescence spectrometry.

2.3 Statistical methods

All statistical analyses were performed using SPSS 16.0 for Windows (IBM, Chicago, IL, USA). The statistical significance was set at $p < 0.05$. In addition, ArcGIS version 10.0 (Esri, Redlands, CA, USA) software was used to generate distribution maps of longevity indexes and element concentration. Microsoft Excel was used to draw histograms.

2.4 Equation of bioaccumulation factor

The bioaccumulation factor for Se was calculated in order to assess the extent by which Se occurs in rice and associated soil. Se concentration of cultivated soil was chosen in this equation for it had more direct impact on rice. This was calculated by the equation:

$$BAF = C_{rice} / C_{cultivated\ soil}$$

3.Results

3.1 Concentration of Se in Hainan Province

Table 1 shows the mean concentration of Se in soil samples by county. Se concentrations showed significant regional difference in Hainan Province, they were ranging from 108.41-618.23μg/kg, and the average value was 343.90μg/kg. The highest values presented to Haikou, Wanning and Lingao, while the lowest values to Dongfang, Ledong and Changjiang. It showed that soil in northeast contained more Se than in southwest (Fig.2). Values of most counties as well as the average value were much higher than the background value of soil Se (Table 1 and Fig.3). It indicated that soil in Hainan was loaded with selenium, which may contribute to its residents' health and high percentage of centenarians.

Table 1. Se concentration in soil by counties

Region	Soil	Natural soil	Cultivated soil	p
Baisha	414.80	577.95	297.70	0.000
Baoting	399.65	344.71	463.34	0.001
Changjiang	189.68	171.43	209.88	0.011
Chengmai	314.06	481.59	280.74	0.000
Danzhou	229.08	256.35	204.70	0.000
Ding'an	376.28	360.47	392.77	0.000
Dongfang	108.41	87.15	134.86	0.035
Haikou	618.23	663.10	576.40	0.005
Ledong	121.42	110.06	133.95	0.000
Lingao	507.84	547.36	471.18	0.001
Lingshui	286.29	315.17	260.06	0.001
Qionghai	439.85	453.43	426.69	0.005
Qiongzhong	449.79	538.50	375.69	0.001
Sanya	201.59	212.33	191.40	0.003
Tunchang	349.44	322.26	378.92	0.029
Wanning	555.25	629.39	489.85	0.000
Wenchang	421.94	426.77	417.16	0.003
Wuzhishan	206.51	264.54	167.02	0.013
Average	343.90	375.70	326.24	
Max	618.23	663.10	576.40	
Min	108.41	87.15	133.95	
Background value	216.00			

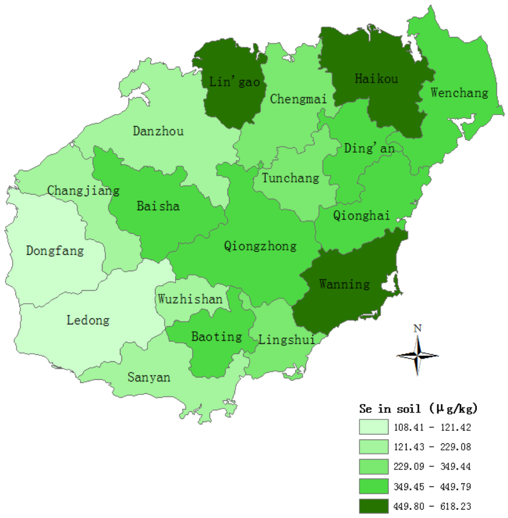
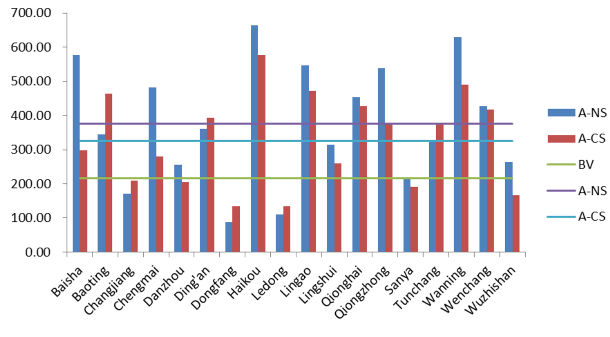


Figure 2. Distribution of Se concentration by counties

3.2 Comparison of Se concentration in natural soil and cultivated soil

The comparison of Se concentrations between natural soil and cultivated soil was also listed in Table 1. Se concentrations of natural soil were ranging from 87.15-663.10μg/kg, and the average value was 375.70μg/kg; Se concentrations of cultivated soil were ranging from 133.95-576.40μg/kg, with the average value of 326.24μg/kg. The average value of Se concentration in natural soil is higher than that in cultivated soil. In order to make the comparison clearer and more visual, histogram was draw as Fig. 3. Except in Baoting, Changjiang, Ding'an, Dongfang, Ledong and Tunchang, Se contents in natural soil were significant higher than in cultivated soil ($p<0.05$). It indicated that cultivated land had caused Se element loss. High level of Se content wasn't caused by cultivation, but benefited from high background value in Hainan soil. By contrast in our related research, for most of heavy metals, which were considered as harmful to human health, their contents in natural soil were significant lower than in cultivated soil ($p<0.05$). It indicated that cultivated land had caused heavy metal to increase. Both these results turned out that quality of natural soil was better than cultivated soil in Hainan, and Hainan had a good soil environment as a whole.



BV: the background value
A-NS: average value of narutal soil
A-CS: average value of cultivated soil

Figure 3. Comparison of Se concentration in natural soil and cultivated soil

3.3 Relationships between soil, rice and C/100,000

In order to explore the potential influence of soil Se on human health, correlation analysis was used to evaluate the relationships between soil, rice and C/100,000 (Table 2). Positive correlations were seen between these three factors. Although the correlations were not statistically significant, it can infer that content of Se in soil has a positive effect on that in rice, and they all contribute to the high level of C/100,000 of Hainan province.

Table 2. Correlation coefficients between soil, rice and C/100,000

	C/1000000	Cultivated soil	Rice
C/1000000	1		
Cultivated soil	0.270	1	
Rice	0.464	0.117	1

Se concentration of rice [9] and the BAFs were listed in Table 3. Values of BAF varied among different counties. They were ranging from 0.06-0.66, and the average value was 0.15. Chengmai ranked the highest value of BAF while Lingao had the lowest value. The BAF reflected the transfer ability of Se from soil to rice, and maybe the reflection of its affect on human health. Higher BAF presented better potential for rice to accumulate Se from soil. However, it's a complex process and needs further studies.

Table 3. BAF of Se from soil to rice

Region	Cultivated soil (μg/kg)	Rice (μg/kg)	BAF
Baisha	297.70	21.24	0.07
Baoting	463.34	44.11	0.10
Changjiang	209.88	31.91	0.15
Chengmai	280.74	185.68	0.66
Danzhou	204.70	30.86	0.15
Ding'an	392.77	56.57	0.14
Dongfang	134.86	35.83	0.27
Haikou	576.40	64.57	0.11
Ledong	133.95	41.59	0.31
Lingao	471.18	28.41	0.06
Lingshui	260.06	33.92	0.13
Qionghai	426.69	46.29	0.11
Qiongzhong	375.69	35.62	0.09
Sanya	191.40	44.85	0.23
Tunchang	378.92	35.24	0.09
Wanning	489.85	65.43	0.13
Wenchang	417.16	57.92	0.14
Wuzhishan	167.02	30.87	0.18
Average	326.24	49.50	0.15
Max	576.40	185.68	0.66
Min	133.95	30.87	0.06

4.Conclusions

This paper analyzed distribution of Se in soil of Hainan Province by counties. Concentrations were ranging from 108.41-618.23μg/kg. The average value was 343.90μg/kg, which was much higher than background value of soil Se. It indicated that soil in Hainan was loaded with selenium, which may contribute to residents' health and high percentage of centenarians. Soil in northeast contains more Se than that in southwest. Se content in natural soil was significant higher than in cultivated soil. Cultivated land may cause loss of Se. Content of Se in soil has a positive effect on that in rice, and they all contribute to the high level of C/100,000 of Hainan province. Values of BAF varied among different counties. They were ranging from 0.06-0.66, and the average value was 0.15.

Acknowledgment
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