Journal of Environmental Sciences (China), Vol. 2, No. 3, pp 99–105, 1990 ISSN 1001-0742

Geographical differentiation of selenium concentration in hair from children and youngsters in China

Wang Mingyuan[1]

(Received December 11, 1989)

Abstract—Selenium concentration in hair are sorted out into three classes, i.e. low (<110 ppb), medium (110–520 ppb) and high (>520 ppb) according to the principle of multiple normal distribution and a map of classification of selenium concentration in hair from children and youngsters in China has been drawn. Selenium insufficiency in relation to Keshan disease and Kashin-Beck's disease is expounded. Geographical differentiation of hair selenium concentrations and its causes are explained.

Keywords: hair selenium; geographical differentiation; Keshan disease; Kaschin-Beck's disease.

INTRODUCTION

Selenium is an essential micronutrient element to human body. A close relationship exists between anomalous concentrations (excess or deficiency) of selenium in environment and epidemic of certain diseases. The hair selenium concentration can be adopted as a criterion of body selenium status recently. Geographical differentiation of hair selenium concentrations might reflect that of absorbing level to selenium by populations. Therefore, mapping distribution of hair selenium in China and investigating geographical differentiation of hair selenium and its affecting factors not only geographically provide an important basis of argument concerning relationship between insufficiency of selenium to Keshan disease and Kaschin-Beck's disease which are endemic unknown causes, but also are of beneficial to geographical investigation with respect to some diseases, health, nutrition and others.

A considerable amount of hair selenium data have been accumulated in China as a result of a programme of study of association of Keshan disease and Kaschin-Beck's disease with selenium insufficiency. The data of selenium in hair from children and youngsters (5–15 years old) have been collected mainly here. Some data are original, totalled up to 855 samples, others are being treated, namely, average content of hair selenium at each site where about ten samples were collected, totalled up to 426 sites. Selenium in hair was usually measured by fluorescence spectrophotometer.

[1]Institute of Geograpy, Academia Sinica, Beijing 100101, China.

DETERMINATION OF CLASSIFICATION INDICATRIX FOR HAIR SELENIUM

Selenium concentrations in hair may be divided into classifications according to the principle of multiple normal distribution and the reason is as follows.

Statistics for 855 samples show that frequency distribution of hair selenium concentrations is subject neither to a normal distribution nor to a lognormal distribution (test of goodness of fit: $X^2 = 254.8$, $df = 13$, $p < 0.001$), but to a positive skew distribution (Table 1 and Fig. 1).

Table 1 Tests of normality of selenium concentrations in hair

No. of samples	Measure of asymmetry		Measure of departure		Significance test			
					g_1		g_2	
	g_1	δ_1	g_2	δ_2	t	p	t	p
855	0.3773	0.0836	-0.4859	0.1671	4.51	<0.001	2.91	<0.001

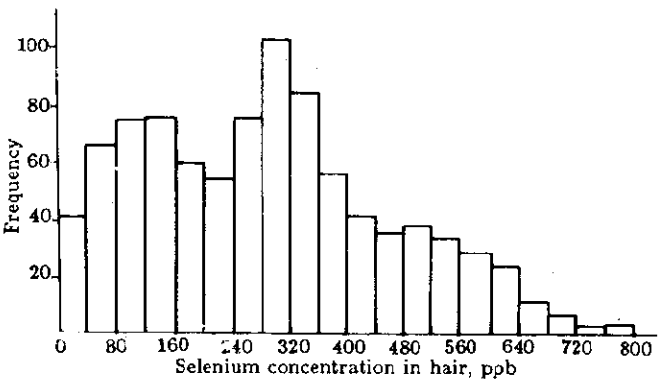

Fig. 1 Histogram for frequency distribution of selenium concentrations in hair

Fig. 2 shows cumulative frequency diagrams of selenium concentration of 855 hair samples and 426 surveying sites plotted on probability paper. Both profiles appear as three broken lines with two intersection points rather than straight lines. In fact, it is a mixed population of threefold normal distribution, which is made up of three juxtaposed truncated normal distribution. Thereby, these data come from three independent populations. On this diagram, each straight-line represents one population and the two points of intersection represent threshold levels among three populations. Whether 855 samples or 426 surveying sites, their two points of intersection on the diagram stand at the same level: 110 ppb and 520 ppb. For this reason, these two points of intersection might be used as classification indicatrix. Different selenium concentrations in hair were divided into three classes, i.e., the low concentration (<110 ppb), the medium concentration (110–520 ppb) and the high concentration (>520 ppb). A distribution map of selenium concentration classification in hair from children and youngsters in China

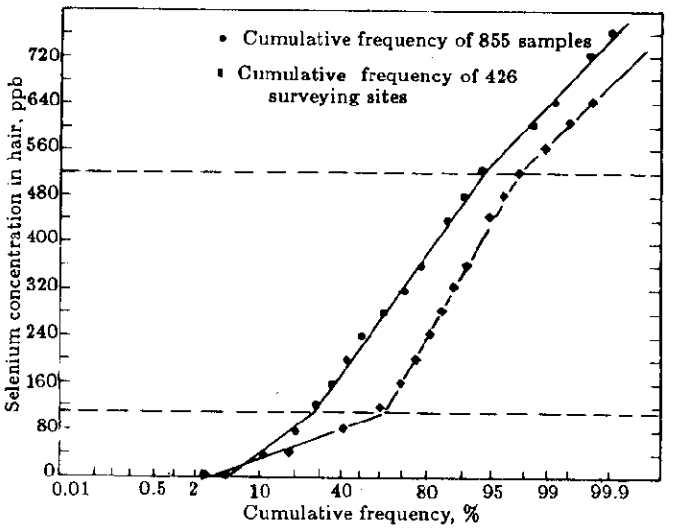

Fig. 2 Cumulative frequencies of selenium concentrations in hair

has been drawn according to these three classification indicatrix of hair selenium. It seems that this map not only illustrations regional difference of hair selenium concentrations, but also coincides with the real distribution.

GEOGRAPHICAL DIFFERENTIATION OF SELENIUM CONCENTRATIONS IN HAIR

As shown in Fig. 3, geographical differentiation of selenium concentrations in hair is quite evident and follows certain rule.

Hair samples of the low selenium (<110 ppb) are mainly located in the so-called transitional zone, situated between the dry desert and grassland zone of Northwestern China and humid forest zone of Southeastern China. It ranges from northeast to southwest, namely, starting from Greater and Lesser Khingan Mountains, through Changbai Mountains, Yanshan Mountains, Luzhong Mountains, Qinling Mountains, Daba Mountains, Loess Plateau, Yunnan-Guizhou Plateau to Eastern Qinghai-Xizang Plateau. The vast low selenium zone is fundamentally in accordance with epidemic zone of Keshan disease and Kaschin-Beck's disease of man and white muscle disease of animal. As shown in Table 2, arithmetic mean of hair selenium concentration in nonendemic area of above mentioned endemics is about four times as high as that in endemic area. As shown in Table 3, there is a very significant difference in constitution of selenium concentration grade of hair between the endemic and nonendemic areas, that is, selenium concentration grade of hair in the endemic area is constituted from the low selenium class (80.2%) and the medium selenium class (19.8%), and the high selenium class is absent. While in the nonendemic area, there is mainly constituted from the medium selenium class (84.2%), and the high and low selenium classes only appeared 8.4% and 7.5% respectively.

Hair samples of the medium selenium (110–520 ppb) are mainly located in humid-hot evergreen forest zone of Southeastern China, dry desert and grassland zone of Northwestern China and large plains and large basins within the so-called transition zone.

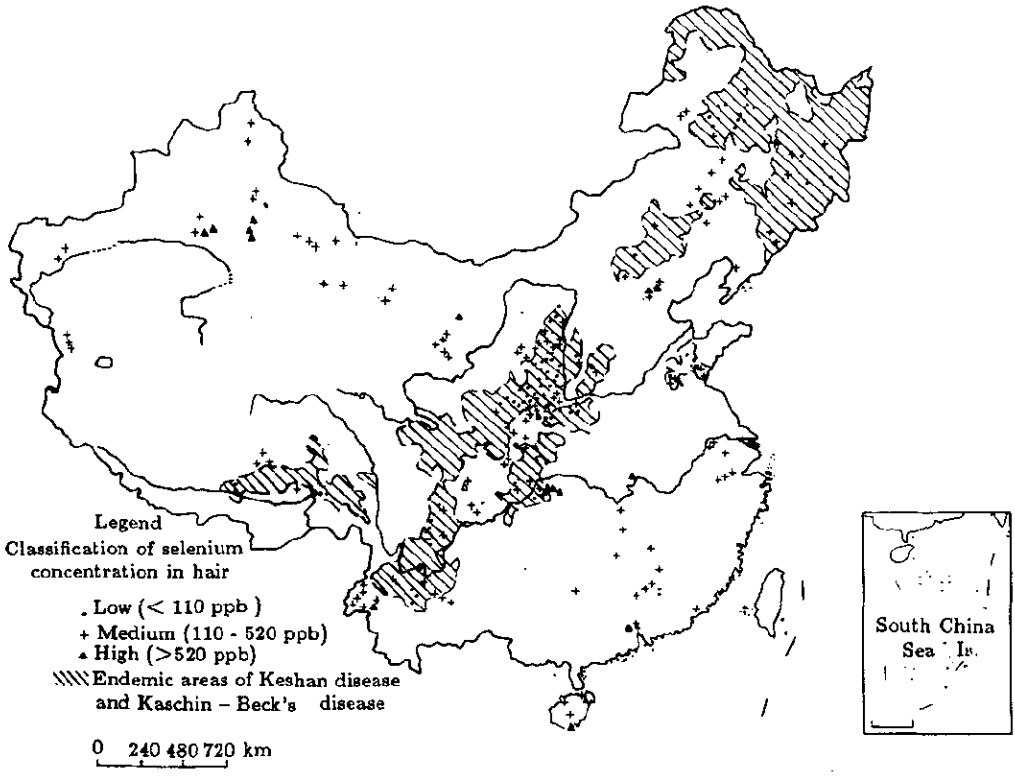

Fig. 3 Geographical distribution of selenium concentration in hair from children and youngsters in China

Table 2 Basic statistical values of hair selenium

Item	No. of samples	Arithmetic mean	*SD*	Median	Mode	*CV*, %	Geometric mean	*SD*
Endemic area	211	92.9	56.88	83.7	60.0	61.2	72.7	1.93
Nonendemic area	644	344.6	139.75	326.1	317.8	40.6	324.0	1.53
Total	855	282.5	163.99	283.3	301.7	58.0	224.3	2.25

N. B. All units are ppb.

Table 3 Comparison of constitutions of selenium concentration classification of hair between the endemic and nonendemic area

Classification of hair selenium concentration		Low	Medium	High	Total
Endemic	Surveying sites	170	42	0	212
area	%	80.2	19.8	0	100
Nonendemic	Surveying sites	16	180	18	214
area	%	7.5	84.1	8.4	100
Significance	tests	$X^2 = 231.4$,	$n'=2$,	$P<0.001$	

Hair samples of the high selenium (>520 ppb) are mainly located in dry desert and grassland zone of Northwestern China, big cities (Beijing, Wuhan, Xi'an, Chengdu, Guangzhou and so on), districts occurring selenosis in livestock and man (Ziyang County of Shaanxi Province and Enshi County of Hubei Province) and coastal areas.

THE ELEMENTARY CAUSE FOR GEOGRAPHICAL DIFFERENTIATION OF SELENIUM CONCENTRATIONS IN HAIR

Selenium in environment has an influence on human body by means of biogeochemical food chain (rock-soil-water-plant-animal), of which grain is the key link. Grain is the staple food for inhabitants, particularly peasants in China. While consumption of foodstuff, such as meat, fish, egg and milk and so on is not very much. Grain, of course, is the major source of selenium to human body. Geographical differentiation of selenium concentrations in grains (rice, wheat and corn) is quite evident, so it would play an important role in geographical differentiation of selenium concentrations in hair.

There are 119 units of county level (including county, city and qi) with data of selenium, concentration both in grain and in hair. Above all, geometric mean of selenium in grain and arithmetic mean of selenium in hair at each unit are calculated respectively, because the former belongs to the approximately lognormal distribution and the latter belongs to the approximately normal distribution. Then the correlation between hair and grain in respect of selenium concentration is calculated. It shows positive relationship and the correlation coefficient $r=0.83$, $p<0.001$ (Fig. 4).

The author has drawn a map of selenium concentration classification in grain of China (Wang Mingyuan, 1982). So long as this map is compared with Fig. 3 in the present paper, it may be seen that the geographical differentiation of selenium concentrations in hair are accordant with that in the grain, that is, the low selenium zones both in hair and in grain are coincident with the endemic zone of Keshan disease and Kaschin-Beck's disease.

In the low selenium zone, selenium concentration of corn is usually below 19 ppb and that of wheat and rice is usually below 20 ppb.

In addition, hair selenium concentration in inhabitant who consumes a considerable amount

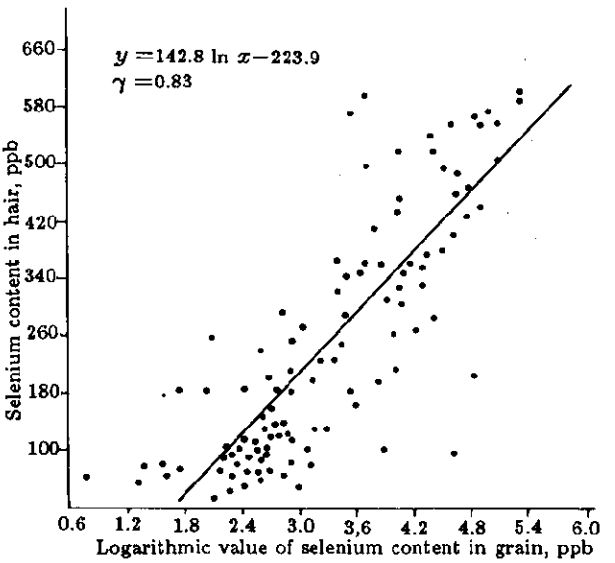

Fig. 4 Relationship of selenium concentration between grain and hair

of meat and fish, such as herdsman and fisher, is usually higher than that of other inhabitant who consumes little amount of meat and fish, such as peasant. Hair samples obtained from big cities contain higher selenium, which may be related to diet of urbanite, because urbanite consumes much more meat, fish and refined grain (rice and flour) in ration, and these grains are a principal product from plain. Our data show that the average selenium concentrations of wheat and rice in our country are two to four times as high as that of corn and selenium concentration of grain crop harvested in plain is usually much higher than that of mountainous district.

CONCLUSIONS

Because frequency distribution of selenium concentration in hair from children and youngsters in China appears as three-fold normal distribution, these two points of intersection on probability paper, representing the thresholds level of these three normal distribution, are adopted as the indicatrix of classification of selenium concentration in hair. Selenium concentrations in hair may be divided into three classes: low (<110 ppb), medium (110–520 ppb) and high (>520 ppb). And a map of selenium concentration classification in hair from children and youngsters in China has been drawn. It may be seen from the map that the geographical differentiation of hair selenium is clear and Keshan disease and Kaschin-Beck's disease are mainly situated in the low selenium zone, where selenium concentrations in hair and grain are usually below 110 ppb and below 20 ppb respectively. There is significant linear correlation between grain and hair in concentration of selenium (r=0.83, p <0.001), and geographical differentiations of both hair and grain are also coincident well. Therefore, geographical differentiation of selenium concentrations in grain is the primary cause in that of selenium concentrations in

hair.

Acknowledgements—The author would like to express his thanks to the Institute of Geography, the Institute of Forestry and Soil Science and the Institute of Water-Soil Conservation of Academia Sinica, the Keshan Disease Research Group of the Chinese Academy of Medical Sciences and the Xi'an Medical College and so on for offering their unpublished materials, to Prof. Zhang Piyuan and Associate professor Zhang Li of the Institute of Geography of Academia Sinica.

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