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THE PROBLEM OF SELENIUM DEFICIENCY IN SERBIA

Z. Maksimovic[1]

ABSTRACT

Data on Se-deficiency in Serbia are presented. The results include Se contents of rocks, stream sediments, soil, cereal crops and garlic grown in the investigated soil, and human serum and scalp hair from several towns and regions. All data indicate a serious Se-deficiency. Analyses of human tissues show a very low Se-status of Serbian population. In some regions, Se contents of grains, garlic and human serum and scalp hair are approaching those of the low-selenium zone in China. It is assumed that the very low Se-status of the human population could be a risk factor in the development of Balkan Endemic Nephropathy (BEN) and a high incidence of cancer of all sites in endemic areas.

INDRODUCTION

For mote than 35 years Se has been recognized as an essential nutrient to mammals and birds. Well-defined deficiency syndromes have been described in domestic animals and fowls. In humans, Se was found to have protective effects against a fatal cardiomiopathy, known as Keshan disease (Yang et al., 1984), and prophylactic and therapeutic effects against Kaschin-Beck disease, an endemic osteortopathy that occurs in the low-Se belt in China (Liang et al., 1986). Cancer, cardiovascular disease and muscular disorders were also discussed in connection with Se-deficiency (Selenium, WHO, Geneva, 1987, Scrauzer, 1992, Van Vleet et al., 1992). A hypothesis that very low Se-status of the human population in Serbia possibly plays an important role in the development of BEN was recently proposed (Maksimovic, 1987, 1991).

In this paper available data on Se-deficiency in Serbia are summarized, based on a team work during the last 10 years (Maksimovic et al., 1985, 1989, 1991, 1992).

ANALYTICAL PROCEDURE

In all samples, after wet digestion, Se was determined by hydride generation AAS. A Perkin Elmer atomic absorption spectrometer 5000, equipped with hydride generation system (MHS 10), was used. Different digestion procedures were used for geological and biological materials, and serious precautions were taken to prevent any loss of Se during this procedure (Maksimovic et al., 1991). The limit of detection was about 2 ng Se mL^{-1}. Reproducibility of the technique was from -24 % to -2 %, depending on the concentration of Se. The accuracy of the analysis was monitored by inclusion of international reference samples in the analytical program (Maksimovic et al., 1992).

1 Faculty of Mining and Geology, Djusina 7, 11000 BELGRADE, Serbia

SELENIUM IN STREAM SEDIMENTS

The first geochemical investigation of Se in Serbia, on a large scale, started on stream sediments (Maksimovic et al., 1985). The results obtained have shown that Se is more or less uniformly distributed in river sediments and the averages between different regions had small variations. The mean Se content of stream sediments, fraction <50 µm, was 229 µm/kg Se. It was much lower that the mean Se of soils in many countries (Thornton et al., 1983). The low Se content of the stream sediments, in spite of the contribution of selenium in numerous sulfide mineralizations, was the first indicator of Se-deficiency in the large part of the country.

SELENIUM IN IGNEOUS AND METAMORPHIC ROCKS

Selenium was determined in 285 igneous rock samples, including intrusive and volcanic rocks (Maksimovic et al., 1992). The overall average of 46 µg/kg Se is very close to the value of 50 µg/kg Se proposed by Turekian and Wedepohl (1961) and Vinogradov (1962). Selenium content shows a general tendency to decrease from mafic to more acid rock types. Volcanic rocks are more depleted in Se than their intrusive and dike equivalents. The most widespread igneous rocks are those of intermediate composition. They are very poor in selenium, especially their volcanic equivalents, which are extremely depleted in this element (x=22 µg/kg Se, n=90).

The average Se content in 89 samples of various metamorphic rocks is 28 µg/kg (Jovic et al., 1993). It was concluded that a great part of Se was lost from rocks during metamorphic processes at high temperature and pressure.

Very widespread volcanic rocks of intermediate composition and metamorphic rocks, both very depleted in Se, are the source of Se-deficient soil. Therefore, Se-deficiency partly originate from these Se-poor rocks, which built up vast volcanic and metamorphic areas in this country.

SELENIUM IN SOIL, WHEAT, CORN AND GARLIC

Samples of surface soil, and wheat, corn and garlic grown in these soil, were collected from several agricultural regions in Serbia, including plains in the north (Banat), river valleys of the Great Morava, West Morava, Drina and Kolubara rivers, as well as hilly areas of the west and central Serbia.

Soil

Se-content of soil derived from volcanic rocks of East Serbia is very low, x=126 µg/kg Se (Jovic, 1990). All other investigated soils were derived from sedimentary rocks of different age and composition (from quaternary to Paleozonic). They are all poor in selenium. The mean content of Se in 140 soil samples from 29 communities in Serbia is 200 µg/kg, a value about twice lower than those found in soil from other regions of the world (Thornton et al., 1983). The range of selenium in the soil, 79 to 439 µg/kg Se, shows that the highest value found in the soil is less than 500 µg/kg, which is considered as upper limit for Se-deficient soils (Mayland et al., 1989).

Results for soils, grain and garlic are summarized in Table 1.

PH of soil varies from 4.45 to 8.33, the acidic to neutral soils being the most frequent. These conditions promote low availability of selenium in plants. Se extractable with 1N NH_4Oac varies from 1.2 to 27.6 % of the total, depending mostly on pH of the soil. The highest pH of soil was found in the areas of south Banat in the northern Serbia, where amounts of extractable selenium was the highest.

Table 1: Se content in Serbian soils, wheat, corn and garlic

	n	Mean ± SD µg/kg
Soils	140	200 ± 69.6
Wheat	58	20.5 ± 12.4
Corn	79	13.7 ± 13.6
Garlic	66	13.7 ± 17.1

n=number of samples; wheat, grain and corn of dry wt basis and garlic fresh after peeling.

Wheat

Se-content of wheat from Serbia is low and ranges from 3.6 to 65.5 µg/kg with the mean value of 20.5 µg/kg Se from 58 samples. There are wide variations of the Se-content of wheat in various regions. The highest concentration was found in two communities in the central Serbia (Zabari and Svilajnac) ($\bar{x}$=39.2 µg/kg; n=3) and in the Banat areas, north Serbia (x=25.2 µg/kg; n=31). The lowest value of selenium originate from hilly areas of the west Serbia ($\bar{x}$=9.4 µg/kg; n=14), where pH of the soil is acidic. It should be noted that Kechan disease in China affects children and young women in areas where the mean level of Se in staple grains is less than 25 µg/kg (Diplock, 1986).

Corn

Corn is very poor in selenium, in the range of 2.8 to 82.0 µg/kg, with the average of 13.7 µg/kg Se from 79 samples. Two communities in the central Serbia (Zabari and Svilajnac) have the highest Se-content in corn ($\bar{x}$=58.9 µg/kg; n=3). However, most of the communities have extremely low Se levels in corn (<10 µg/kg). These values correspond to those found in corn in the low-Se belt in China (Xu and Jiang, 1986). They also correspond to values found in corn from Pozega Valley in Slavonija, Croatia, where mass occurrences of Se responsive diseases in domestic animals are connected with Se deficiency in soil and fodder (Gavriloc and Matesic, 1986).

Garlic

Garlic is known to accumulate more selenium than most of other crops. The highest content of 81.40 µg/kg Se was found in garlic from seleniferous soil in the Enshi County, China, where chronic selenosis in human population was recognized (Yang et al., 1983). Reported Se content in garlic from U.S.A. was 250 µg/kg (Morris and Levander, 1970) and 600 µg/kg (Mikkelsen et al., 1989). Compared with these levels in the U.S.A. one reported value from United Kingdom of 20 µg/kg is very low (Thorn et al., 1978).

Garlic is very popular vegetable in Serbia and is grown practically in every garden. Garlic and soil were collected from 66 sites in 21 communities. The analyses revealed wide variations of Se level in garlic from different regions, with the mean content of 13.7 µg/kg Se,. The highest content was found in three communities in the north Serbia (Banat), with average of 35.4 µg/kg Se from 13 sites. In these cases total and extractable selenium was relativelyhigh and the soil was alkaline. Two communities with a moderate Se content in wheat and corn in the central Serbia (Zabari and Svilajnac) have higher Se content than the overall average in Serbia (x=18.9 µg/kg; n=5). However, most of the communities have extremely low Se levels in garlic (<10 µg/kg), not reported in the literature so far.

SELENIUM IN HUMAN SERUM AND SCALP HAIR

In recent years it has been establishes beyond doubt that selenium is also essential to humans and diseases and death resulting from Se-deficiency have been described (Chen et al., 1980; Xu and Jiang, 1986).

In order to examine the levels of selenium in serum and scalp hair of Serbian population and subsequently to correlate these with the incidence of degenerative diseases in the respective areas, a collaborative study started in 1988 under the auspice of Serbian Academy of Sciences and Arts in Belgrade.

The samples of human serum and scalp hair were obtained from healthy individuals, aged 20-50, from several towns and regions, but not including villages with BEN.

In this country interchange of foodstuffs occurs from one district to another. However, low selenium content in soil and grain in the main agricultural regions is reflected in the low Se-status of human population. Serum Se-levels for a combined male and female population from the individual regions in Serbia are summarized in Table 2.

Presented data indicate a Se deficiency in human population in Serbia.

Table 2: Mean serum Se-level in healthy population aged 20-50 from various parts of Serbia

Location	n	Mean Se	±SD µg/L
Vojvodina (north Serbia)	109	45.0	16.2
Belgrade area	303	47.7	24.7
Central Serbia	15	47.0	18.2
West Serbia	18	32.1	19.5
East Serbia	59	38.3	17.7
South Serbia	98	37.9	20.9
Serbia	602	44.2	±19.5

Serum Se-levels are lower than in any country in Europe (Thorling et al., 1986). Epidemiological investigation in Finland has demonstrated an increased risk of cancer in people with serum Se-levels at 45 µg/L and below (Salonen et al., 1985). This border line deficiency may be present, according to Thorling et al., 1986, in part of the Greek population. In Serbia the areas with the mean Se-levels below 45 µg/L are quite common (Fig. 1).

High correlation (r=0.85) was found between Se-levels in serum and scalp hair. The Se-content in hair is very low in all investigated areas, approaching those in the Se-deficient zone in China.

Table 3: Mean Se levels in scaip hair of helathy population aged 20-50 from various parts of Serbia

Location	n	Mean Se	±SD µg/L
Vojvodina (north Serbia)	72	91	21
Belgrade area	246	96	17
Central & West Serbia	12	109	14
East Serbia	44	89	22
South Serbia	6	88	14
Serbia	380	94	±16

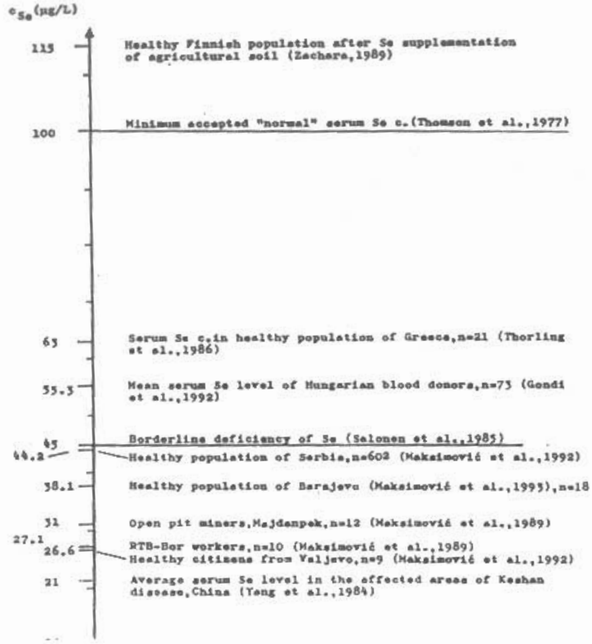

Fig. 1: Mean serum Se-levels of healthy population from Serbia, compared with those from some other countries.

All those results demonstrate that low Se-status of Serbian population correlates with low Se content of food supplies.

Se DEFICIENCY AND POSSIBLE EFFECT ON HEALTH

There is no record in Serbia of specific disease in humans caused by Se deficiency. However, series Se deficiency could be one of the main etiological agents of BEN and high incidence of Urinary Tract Tumors (UTT) in endemic areas (Maksimovic. 1987; Maksimovic et al., 1989; Maksimovic, 1991). Geographic correlation between BEN and the highest incidence of UTT were established in Yugoslavia and Bulgaria (Petrovic, 1968; Chernozemsky et al., 1977). This high percentage of UTT in patients and regions with BENN is indicative of a common etiological agent that has nephropathogenic and carcinogenic effects.

So far, Se deficiency is the only observed common demoninator for all endemic areas. Taking into account the biological function of Se (Diplock, 1981), an underlying significant Se deficiency may predispose individuals to potentially nephrotoxic and carcinogenic agents. These data suggest that research of BEN and UTT in endemic areas is a critical avenue to explore.

Results of current research on Se levels in patients from Serbia with cancer (276 subjects) and myocardial ischemia (20 subjects) show that these patients have lower Se levels for about 20 % compared to controls (Maksimovic et al., 1992). Based on these data and those reported for population groups in other countries (Combs and Combs, 1986), it appears that Se is a possible dietary inhibitor of cancer and myocardial ishemia promotion.

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