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Blood Lead Level as a Criterion of Global Pollution

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Heavy metals in various environmental samples have been determined in the last decade. Data for air, waters, sediments, soil and food have been obtained but little attention has been devoted to continuous monitoring and study of metal intoxication of human beings. The upper concentrations of many heavy metals in air, water and some foodstuffs are regulated by law or norm. But there is no standardization of heavy metal determination in biological and human materials, e.g. organs, tissues, hair, bones, and body liquids or excrements, though the intoxication by heavy metals is known since antiquity. The analyses of old Roman wines proved that in 1 liter were about 20 mg Pb and so we can assume that a Roman aristocrat consumed a few tens of milligrams of lead daily.

Nowadays the daily intake of lead should not exceed 0.2 mg or 0.15 mg for adults or children respectively, because lead is a toxic element. A great deal of this amount is supplied by drinking water, which generally contains 2-20 $\mu g.L^{-1}$ of Pb or, in accordance with the Czechoslovak norm ČSN 75 71 11, less then 50 $\mu g.L^{-1}$. The whole amount of lead in a living organism is also contributed by nutrition. A high concentration of lead in foodstuffs can be accumulated from natural sources (average concentration of Pb in Earth crust is $1.6x10^{-3}$% w/w) as well as from anthropogenic sources as industrial and automobile pollution. In addition, lead enters the organism not only through the alimentary chain but also through the respiratory system. The upper level of lead in air allowed by the WHO is 2 $\mu g.m^{-3}$. Lead occurs in air mainly in particles of dust.

Lead, a typical heavy metal with cumulative and nondegradative characteristics, enters the blood, lymph, and organs where its concentration remains constant for a long

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time. Only little lead is excreted by urine and sweat, where its concentration is lower than in blood. The concentration of Pb in whole blood is higher than in plasma or serum.

There are no data characterizing the concentration of Pb in biosphere, human organs, and liquids from the time before the industrial revolution. Even a few results, which were obtained before the World War II, cannot be accepted with regard to the low standard of analytical instrumentation of that time. We can only estimate the level of lead in those materials on the basis of today's analyses of anthropologic or archaeologic remains like bones, hair, teeth, seeds, etc. The achieved results indicate the global ascent of environmental lead.

In the present work we have determined the lead concentration in whole human blood of middle aged population of Bratislava city, Czechoslovakia. Blood is a sample which can be obtained very simply during the life of a donor so that it can be used for environmental quality testing with time. Lead was chosen for our study because its rapid growth in the environment caused by an increase of the lead production and automobile traffic.

MATERIALS AND METHODS

The analyzed samples came from healthy working women and men, age 30-57, not professionally exposed, living in the central and eastern part of Bratislava where there are neither glassworks nor lead industry. Our results were obtained from whole blood of 80 donors (160 samples). The blood samples, 100-300 µL or more, were mineralized in the quartz cells with equal volume of concentrated H_2SO_4 in furnace at 150°C for 2 hr, then at 300°C for 2 hr and at 500°C for 3 and more hr. The higher volumes demand longer time for ashing. The obtained white ash was dissolved in the hot mixture of 50 µL of concentrated HNO_3 and 50 µL of concentrated HCl and diluted with high purity demineralized water to 2 mL.

Bivalent lead was determined using the anodic stripping voltammetry on the mercury static electrode after deposition at -0.6 V for 80 sec in differential pulse fast scan mode by Polarographic Analyzer PA3, Prague, Czechoslovakia. The concentration was calculated by the linear regression using the standard addition method. The detail procedure is described by Kalavská (1989).

RESULTS AND DISCUSSION

The content of lead is monitored in many materials to check observing hygienic norms. The growth of lead content in plants, fruits, soils, seeds in vicinity of highways and also in milk and meat of cows pastured here was proved. The Pb level in water, foodstuffs, corn, fruits, vegetables, tobacco, and tins is regularly monitored in many industrial countries. In 1972 the Joint FAO/WHO Expert Committee recommended that the intake of lead via the diet should not exceed 3 mg for an adult per week. The average values of Pb concentration in some mentioned materials are shown in Table 1.

Table 1. Content of lead in some materials

Material	Range of content	Unit
Surface and drinking waters	2 - 15	$\mu g.L^{-1}$
Rain waters in urban areas	4 - 30	$\mu g.L^{-1}$
Atmosphere in urban areas	1 - 10	$\mu g.m^{-3}$
Atmosphere in rural areas	0.1 - 1	$\mu g.m^{-3}$
Soil in rural areas	2 - 200	$\mu g.g^{-1}$
Inorganic fertilizers	2 - 40	$\mu g.g^{-1}$
Vegetables and cereals fresh wt	0.1 - 1	$\mu g.g^{-1}$
Mushrooms fresh wt	0.008 - 0.04	$\mu g.g^{-1}$
Milk	2 - 6	$\mu g.L^{-1}$
Human urine and sweat	10 - 100	$\mu g.L^{-1}$
Human bones and teeth	0.2 - 20	$\mu g.g^{-1}$
Human organs wet wt	0.1 - 2	$\mu g.g^{-1}$

The analyses of human blood of the professionally exposed workers as galvanizer, miner, smelter, and welder proved the increase of Pb concentration (van Netten at al. 1987; Cornelis 1988). After the intake of a complexing agent (e.g. EDTA) lead binds into the chelate and partly excretes in urine.

Our results in Table 2 show the level of blood lead in a group of citizens which represents the population of Bratislava. These results show the middle level of blood lead in comparison with the results of the other authors (Rummo et al. 1979; Nürnberg 1979; Lynam et al. 1981).

The level of blood lead can be used as an indicator of global pollution which indicates a nonideal state in Bratislava, especially in comparison with the level in Scandinavia (Lynam et al.1981).

The levels of lead in human blood published by several

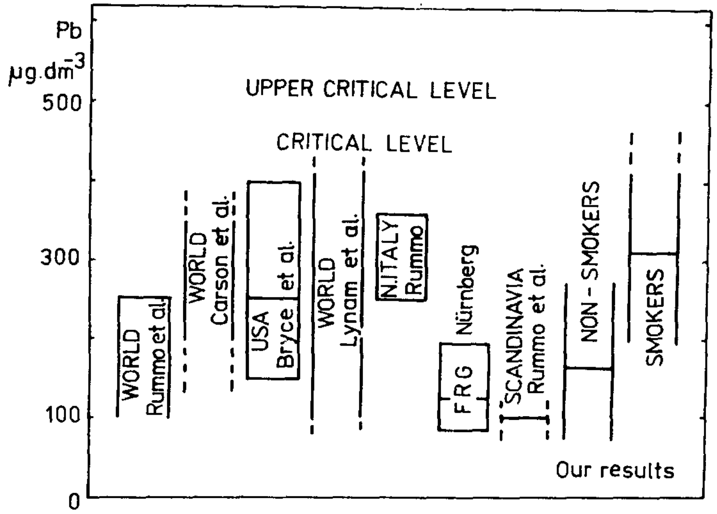

Figure 1. Average concentration of lead in human blood by several authors

authors are shown in Figure 1. In all cases the samples of blood came from the regions which were not extremely polluted by lead. The showed results are comparable with the results from the others industrial regions.

According to Bryce-Smith at al. (1978) the upper level of lead in normal blood in the USA is 400 and the average level is 250 µg.dm^{-3}. Lynam et al. (1981) reported the range 110-300 µg.dm^{-3} for 88 % of the world adult population. Carson et al. (1986) found that the lead level < 350 µg.dm^{-3} for 90 % of population and Rummo et al. (1979) wrote about < 100 µg.dm^{-3} Pb in blood of Scandinavians, while in industrial North Italy it was 240-350 µg.dm^{-3}. Nürnberg's results (1989) from medium-industrial town of Jülich, Germany were in the range 70-190 µg.dm^{-3}. Mahaffey et al.(1982) published 139 µg.dm^{-3} as the average in the USA. On the basis of the children data in the USA (Ernhart et al. 1988) it can be supposed that the average level for adults must be over 170 µg.dm^{-3} in that country. It is generally admitted that the adults have a higher level of lead in blood than children. In our opinion the average depends on age of a man. The old people have higher Pb content than the young ones because of the cumulative ability of this metal. The world average of blood lead is represented in Figure 2.

In this assumption the conclusion published by Boeckx (1986) might be accepted. He correlated the growing blood lead concentration with health of children and adults.

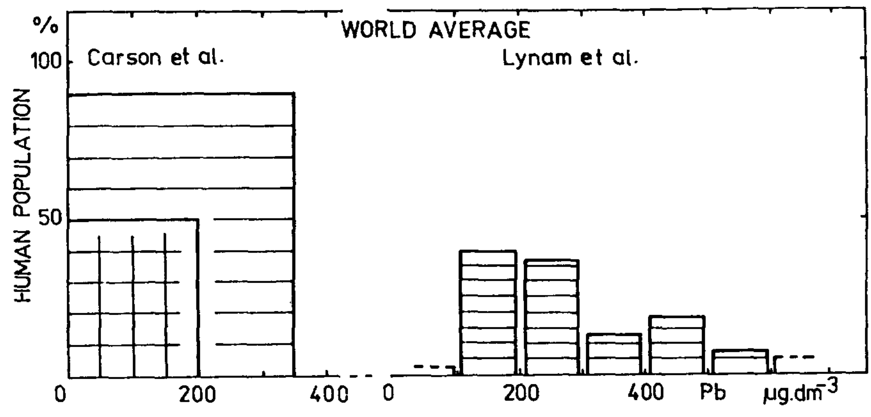

Figure 2. Distribution of human population in the ranges of blood lead concentration

The concentration of about 400 $\mu g.dm^{-3}$ causes the inhibition of enzymatic δ-ALAD and blood creating processes in children. In the range 400-500 $\mu g.dm^{-3}$ anemia, in 500-600 $\mu g.dm^{-3}$ cognitive defects occur. In the range of 600-700 $\mu g.dm^{-3}$ encephalopathy and in the range of 800-1000 $\mu g.dm^{-3}$ death occurs. It is generally admitted that the critical lead concentration in whole blood is 400-500 $\mu g.dm^{-3}$ and above this level there is no healthy or professionally nonexposed man.

There are few data about drug addicts, alcoholics and smokers. In the paper of Lansdown and Yule (1986) the level of blood lead for smokers is published which is 10-15 % higher than in nonsmokers. Ernhart et al. (1985) proved the increase of lead concentration in fetal blood according to the growing number of smoked cigarettes of the mothers. The study of blood lead level of drug addicts and alcoholics also proved a correlation with the intensity of this activity. According to results of Vives (1980), the alcoholics can have a blood lead concentration higher than 690 $\mu g.dm^{-3}$. Dally et al. (1989) published the mean blood lead in alcoholics 280 $\mu g.dm^{-3}$ and the highest value 725 $\mu g.dm^{-3}$. In this context we must consider an enhanced mortality of lead workers with high blood lead, where cancer is very often the cause of death (Fanning 1988).

The data of blood lead level of 80 inhabitants of Bratislava, Czechoslovakia, are published in this paper. It was confirmed that the monitoring of lead concentration in blood can be used for testing condition of donors and for evaluating the environment in global. The obtained data of nonsmokers can be used for the classification of

Table 2. Results of the determination of lead in whole blood

Sample donor	Age range (yr)	Number of persons	Number of samples	Range ($\mu g.dm^{-3}$)	Average ($\mu g.dm^{-3}$)
Women nonsmokers	35-55	15	30	80-230	160
Men nonsmokers	30-39	15	30	70-240	150
Men nonsmokers	40-57	20	40	90-250	180
Men and women smokers	35-57	30	60	180-450	300

pollution of the monitored people and region. It seems that a high contribution to blood lead comes from smoking and blood lead level depends also on age of the man.

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