THE LEVEL OF NICKEL IN SMOKER'S BLOOD AND URINE

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SUMMARY

General population is exposed to nickel from various sources. Smoking presents a significant form of exposure. The research was conducted in period 2000–2003 in Institute of Public Health in Nis. The samples of tobacco and cigarettes (127 samples) were both domestic and imported, and samples of biological material (123 blood samples and 147 urine samples) were taken from occupationally unexposed persons (smokers and non-smokers). The analyses were performed by electrothermal atomization technique, by Perkin Elmer AAS M-1100.

The results obtained, revealed a high content of nickel in cigarettes (2.32–4.20 mg/kg) and in tobacco (2.20–4.91 mg/kg) regardless of the kind and the origin of tobacco. Nickel content in the blood of smokers (0.01–0.42 µg/l, median 0.07 µg/l) was higher than in the blood of non-smokers (0.01–0.26 µg/l, median 0.06 µg/l) although this difference was not statistically significant ($p>0.05$). In the urine of smokers (<0.01–8.20 µg/l, median 1.20 µg/l) there was a significantly higher concentration of nickel than in the urine of non-smokers (<0.01–4.60 µg/l, median 0.50 µg/l), $p<0.05$.

The exposure of smokers to nickel through tobacco smoke was high regardless of the kind and the origin of tobacco and cigarettes. The content of nickel in tissue fluids established by biomonitoring shows that smokers can be far more exposed to this carcinogenic substance than non-smokers and that health risks for smokers are higher in this context.

Key words: nickel, cigarettes, exposure, blood, urine

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INTRODUCTION

Nickel comes into environment both from natural sources and as a product of human activity (anthropogenic nickel sources). It is found in all spheres (atmosphere, lithosphere, hydrosphere and biosphere) in small concentrations. It influences physical and chemical processes in outer environment biological processes in living organisms.

Natural sources of nickel in air are volcanic eruptions and earth dust; with other natural sources have significantly lower participation. Man himself is the greatest polluter by means of combustion of oil and its derivates, primary processing of nickel ores and incinerator operation (1).

A significant source of nickel exposure for occupationally unexposed population is the inhalation of tobacco smoke. Nickel in tobacco smoke is present in form of gaseous phase or particles. A special toxicological significance is attributed to nickel carbonyl, a compound found in tobacco smoke, which passes through alveolar barrier very quickly after inhalation. Since alveolar membranes contain phospholipids, fat solubility of nickel carbonyl is of great importance for its good penetration through the membrane.

After the absorption, nickel enters the blood, attaches itself to protein carriers and reaches by means of bloodstream all organs and tissues (2). The existence of trans-placental transfer of nickel is confirmed and it represents the very beginning of exposure which is continued after birth due to environmental factors (3). Certain amounts of nickel are introduced to infants by means of mother's milk (4).

Nickel elimination from an organism can be performed in several manners (sweat, biliary system, feces, hair, nails, and elimination through nursing, umbilical cord and placenta), but urinary excretion is considered the most important. People exposed to nickel in various ways are found to have increased nickel content in their urine.

Nickel is classified as a carcinogenic substance and its toxic effect on most organs and tissues is established without any doubt (5, 6).

Objective: The purpose of this paper is to establish the exposure of smokers to tobacco smoke nickel and to ascertain, by biomonitoring nickel concentration in body fluids (the blood and the urine) and to estimate the health risk for smokers.

METHODS

This research has been conducted in the Institute for Public Health, Nis, in period 2000-2003. We obtained and analyzed 127 samples of cigarettes and tobacco derivates, 123 blood samples and 147 urine samples. The sampling was done by means of polyethylene plastic vessels which had been previously washed by deionized water and dried. Tobacco and cigarette samples were both domestic and imported, while body fluids samples were taken from healthy, occupationally unexposed persons (18–54

Table 1. *Concentration of nickel in cigarettes and in tobacco*

	Number of samples	Percentiles					Mann-Whitney Rank Sum Test
		Min	C25	C50	C75	Max	
		mg/kg					
Tobacco	56	2.20	3.30	4.51	4.80	4.91	n.s.*
Cigarettes	71	2.32	3.15	3.40	3.96	4.20	

*not differ significantly
(p<0.05 was considered as the criterion of statistical significance)

Table 2. *Concentration of nickel in the blood of smokers and non-smokers*

	Number of samples	Percentiles					Mann-Whitney Rank Sum Test
		Min	C25	C50	C75	Max	
		μg/l					
Smokers	57	0.01	0.02	0.07	0.13	0.42	n.s.*
Non-smokers	66	0.01	0.03	0.06	0.12	0.26	

*not differ significantly
(p<0.05 was considered as the criterion of statistical significance)

Table 3. *Concentration of nickel in the urine of smokers and non-smokers*

	Number of samples	Percentiles					Mann-Whitney Rank Sum Test
		Min	C25	C50	C75	Max	
		μg/l					
Smokers	69	< 0.01	0.50	1.20	3.50	8.20	p<0.05*
Non-smokers	78	< 0.01	0.05	0.50	1.45	4.60	

*differ significantly
(p<0.05 was considered as the criterion of statistical significance)

-year-old). Until the analyses they were kept in the freezer under –20 ºC temperature.

Samples of urine and blood were collected in acid-washed polyethylene containers. Persons who handled samples used talc-free gloves to avoid nickel contamination from sweat. Prior to the determination of nickel in samples of urine these were oxidized by nitric acid at temperatures under 80 °C to remove organic constituents which interfere during analysis. Samples of blood, tobacco and cigarettes were treated at high temperature (400 °C) and residues were dissolved in nitric acid. The analyses were performed, by electrothermal atomization technique, by Perkin Elmer AAS M-1100. The validity of the procedure was checked by the 3x repetitive analysis.

Results of the examinations were processed by mathematical and statistical methods. Percentiles were calculated (C25 = 25th percentile, C50 = 50th percentile or median, C75 = 75th percentile) and Mann-Whitney Rank Sum Test was used to compare the variables, because they were not normally distributed. Statistical significance was set at p value <0.05. The analysis was performed using statistical software SPSS® for Windows™, release 8.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

We established that nickel concentrations in tobacco and cigarettes are high regardless of the brand and the origin (Table 1). Nickel concentrations ranged from 2.20 mg/kg to 4.91 mg/kg in tobacco and 2.32 mg/kg to 4.20 mg/kg in cigarettes. The median of nickel content in tobacco (4.51 mg/kg) was higher than the median of nickel concentration in cigarettes (3.40 mg/kg), but this difference was not statistically significant (p>0.05). It is obvious that tobacco processing during cigarettes manufacture does not significantly reduces nickel content in the final product.

Nickel in the form of nickel carbonyl remains in the lung parenchyma for only a short time and very quickly enters general circulation. The established nickel content (Table 2) in the blood of smokers was higher (the median was 0.07 μg/l) than in the blood of non-smokers (the median was 0.06 μg/l), but this difference was not statistically significant (p>0.05).

Nickel content in urine, established during this research (Table 3) ranged in smokers from undetectable values under 0.01 μg/l to 8.20 μg/l (the median was 1.20 μg/l) and in non-smokers from undetectable levels to 4.60 μg/l (the median was 0.50 μg/l). There is a significant difference in nickel urine content of smokers and non-smokers ($p<0.05$) which shows that smokers are more exposed to the effects of this carcinogenic substance than non--smokers.

DISCUSSION

Similar results concerning nickel content in cigarettes are also mentioned by other authors in their papers: in USA, nickel was present in concentration of 2.3 µg per cigarette, the values ranging from 1.1 to 3.1 µg, while tobacco, cigars and other tobacco derivatives had similar concentration. In Germany, cigarettes have average nickel concentrations of 1.2–4.0 mg/kg (1).

In nickel toxicology, a special place is reserved for nickel carbonyl, a compound soluble in fat phase, which is present in gaseous form in tobacco smoke. A research revealed that 0.04–0.58 µg of nickel is taken through the consumption of one cigarette (8). Consumption of two packs of cigarettes per day includes the intake of 3–15 µg/day, which is 1–5 mg per year (1). Our results show that smoking increases nickel concentrations in the blood of smokers, but many other factors (exposure to other nickel sources, the degree of nickel concentration in other organs, the degree of elimination...) also has influence on the level of blood nickel content. The results of the research of other authors show similar or slightly higher nickel blood concentrations (8, 9, 10). They also concluded that smoking does not have a significant influence on nickel levels in the blood (9, 10).

What most of the researchers agree on is the fact that there are very few researches including biomonitoring of occupationally unexposed population concerning nickel. The same authors propose analysis of blood and urine nickel levels as a reliable and acceptable method of evaluation of environmental nickel exposure (11–15), and TRACY protocol gives referential nickel concentration in blood of <0.05–3.8 µg/l (16).

Research results show reveal similar nickel biomonitoring results in urine of the occupationally unexposed population. In Italy, the values of percentile distribution of nickel in the urine of non-sensitized subjects: C25-0.6 µg/l, C50-2.1 µg/l, C75-1.1 µg/l, which are approximate to the result of our research. Sunderman et al. obtained similar results (8).

It is known that smoking contributes to an increased exposure to various noxious agents, including carcinogens, like nickel, which can have significant negative health effects. Many researches show greater incidence of malignant diseases in nickel exposed workers who are smokers for many years (6).

Based on our result we can conclude that the exposure of smokers to tobacco smoke nickel is high, regardless of the kind and the origin of tobacco. The content of nickel in tissue fluids established by biomonitoring shows that smokers can be far more exposed to this carcinogenic substance than non-smokers and that health risk of smokers are higher. It is necessary to use all relevant means to reduce smoking as a bad and health hazardous habit.

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Received March 29, 2004
Received in revised form and accepted July 26, 2004