Environmental Toxicology and Pharmacology 55 (2017) 196–201

Contents lists available at ScienceDirect

Environmental Toxicology and Pharmacology

journal homepage: www.elsevier.com/locate/etap

Research Paper

The impact of demographic factors, behaviors and environmental exposure to mercury content in the hair of the population living in the region of Lodz (central Poland)

Marta Marcinek-Jacel, Jadwiga Albińska, Aleksandra Pawlaczyk, Małgorzata Iwona Szynkowska*

Institute of General and Ecological Chemistry, Faculty of Chemistry, Lodz University of Technology, Żeromskiego 116, 90-924, Łódź, Poland

ARTICLE INFO

Keywords:
Hair
Mercury
Exposure Factors
Hair analysis
Environmental exposure

ABSTRACT

The aim of this work was to access the influence of different factors such as sex, age, fish consumption, hair dyeing or smoking habit on the content of mercury in human hair samples. The research was carried on 444 samples (102 males and 342 females) collected from the population of people living in the region of Lodz (central Poland). The content of mercury in human hair samples was determined using the Mercury Analyzer MA 3000 (Nippon Instruments, Japan). The obtained results were elaborated using Statistica ver. 10.0 software. The mean value of mercury in investigated human hair samples was found to be 0.174 ± 0.137 mg/kg. We observed the statistically significant correlations ($p < 0.05$) between the content of Hg in hair of the studied population and factors such as gender, age, and fish consumption. However, no statistically significant differences were found in relation to cosmetic treatment such as hair dyeing or smoking.

1. Introduction

Nowadays, when we observe a huge dynamic development of civilization and the intensity of our lives is very high, more and more attention is paid to a healthy lifestyle. Not only is it important what and how we eat, but also what environment do we live in and how it affects our health. It is very well known that the environmental pollution is a product of a developing technology and urbanization. In Europe the rapid development of the industry started in the nineteenth century and was closely connected to the exploitation and processing of metals and later also with coal combustion. These became the largest anthropogenic sources of emissions of heavy metals (Olade, 1987).

At present there is a growing awareness on the topic of heavy metals and their potential poisoning effect on health. Exposure to toxic heavy metals may lead to intoxication or may even pose a particular threat to the health of humans and other living organisms (Szynkowska et al., 2015). Some major poisoning catastrophes in the last century such as Minamata disease in Japan which was caused by the release of methylmercury in the industrial wastewater Chisso's Corporation chemical factory (1953–1970) or mercury poisoning of more than 6000 people in Iraq due to the poisoned flour used for bread baking (1971–1972) also aware the public to the problem of heavy metal poisoning and its potential negative effect on human health (Ki, 1973; Szynkowska et al., 2003; Kłys, 2010).

One of the metals considered as the most dangerous source of global pollution is mercury. It is a highly toxic element for all living organisms. The toxicity of mercury is associated with its high capacity for evaporation, durability, scattering in the environment and being easily bio-accumulative (Szynkowska et al., 2003; Leśniewska et al., 2009; Albińska et al., 2011). Mercury exists in the environment in three forms: as metallic mercury, inorganic salts of mercury and organic compounds. Mercury enters the human body through the respiratory system, skin, and also in food. Exposure to metallic mercury may also come from amalgam fillings and air pollution. Mercury is present in the air in the vicinity of landfills, some municipal and industrial waste, coal power plants, as well as nearby volcanic activity. Inorganic mercury sources come mainly from food and drinking water, and mercury in organic form (methylmercury) found in sea foods, e.g. in fish or seafood (Brodzka and Trzcinka-Ochocka, 2009).

The source of mercury emission can be both from natural processes in the biosphere as well as it may have an anthropogenic origin. In 2010, global emission of mercury to the atmosphere was estimated to be 5200 Mg/year of which those of anthropogenic origin was 2063 Mg/year. According to Pacyna et al. (2016) the current estimates of mercury emissions only from natural sources are estimated to be 5207 Mg/year. It is well known that human activity have a significant impact on emission of mercury to the atmosphere. Mercury is used in the extraction and the treatment of gold, as a catalyst in the production of

* Corresponding author.
E-mail address: malgorzata.szynkowska@p.lodz.pl (M.I. Szynkowska).

http://dx.doi.org/10.1016/j.etap.2017.09.001
Received 11 December 2016; Received in revised form 2 September 2017; Accepted 4 September 2017
Available online 05 September 2017
1382-6689/

plastics, it is used in production of batteries, in dentistry, in electrical and electronic equipment or in the production of pesticides. However, the main source of mercury comes from coal and steel industry. In Poland, determining process of mercury emission to the atmosphere is the process of energy production. In 2010, it accounted for 76.2% of the total emission (Gworek et al., 2013).

The presence of mercury content in the food chain as well as continued release of this toxic metal into the environment caused by human activity pushed the governments to agree to the Minamata Convention on Mercury in 2013 (Poland joined the Convention in September 2014). The aim of the Mercury Convention is to oblige government Parties to take actions, including lowering mercury emissions to the atmosphere and to phase out certain mercury-containing products. (www.mercuryconvention.org).

This is why it is essential to monitor and gather information about the levels of heavy metals in the environment systematically. Environmental biomonitoring may be done by using different kind of body tissues (Juberg et al., 2008). Human hair is known to be one of the most popular bioindicators of environmental and occupational exposure to the toxic elements (Wołowiec et al., 2013). Hair is a highly mineralized tissue, which means that the concentration of elements is higher than in other biological samples ex. blood or urine. What is more the distribution of minerals and chemicals in human hair reflects their contents in the whole organism. This means that there is a correlation between the concentration of chemical elements and compounds in hair, and the actual internal levels of those substances in the body. The mineral content of hair gives a lot of information about the elements stored in internal organs, their mutual correlations and the mineral and metabolic body status (Katz and Chatt, 1988; Szynkowska et al., 2009; Chojnacka et al., 2010; Karaś et al., 2015). Moreover the composition of this biological tissue gives a picture of long-term exposure to the elements or compounds immobilized in the keratin structure of the hair, while blood and urine are useful for evaluating the current, short-term exposure to toxic elements. This might be helpful to see how the exposure changed during time.

The aim of this work was to access the influence of different factors such as sex, age, fish consumption, hair dyeing or smoking habit on the content of Hg in human hair samples. The studied population consisted of people living in the region of Lodz (central Poland). This population represent a group of people who underwent similar environmental exposure (all of them have been living in Lodz for at least 6 months). The obtained results were elaborated using statistical methods and compared to the literature data.

2. Materials and methods

The research was carried on 444 samples (102 males and 342 females) collected from the population of people living in the region of Lodz. The volunteers were asked to fill in a detailed questionnaire (containing questions) about their lifestyle, dietary habits, medication, smoking, etc. The hair content resulting from various factors such as age, gender, tobacco smoking habits, nicotine exposure, hair dyeing and fish consumption was examined.

2.1. Sampling

Prior to the sample collection washed with shampoo (Johnson's Baby) and high purity deonized water (Milli-Q Gradient by Millipore) and cosmetically untreated hair was cut from the place on the back of a head also known as posterior vertex. The selection of the shampoo was determined by its compositionNo additional washing was performed. For this non-invasive operation stainless steel scissors were used. Each sample contained hair from 4 or 5 different locations of the back of a head. The length of the hair used for the analysis was approximately 5 cm or less which corresponds to the period of the past 3–4 months of exposure before the samples' collection. The weight of each sample was 0.2–0.3 g measured with the accuracy of 0.0001 g using the Mettler Toledo analytical balance. The samples were stored in polyethylene bags.

2.2. Analytical methods

The content of mercury in human hair samples was determined using the Mercury Analyzer MA 3000 (Nippon Instruments, Japan). Mercury MA-3000 Mercury Analyzer uses the 253.7 nm wavelength atomic absorption spectrometry method. The 99% pure oxygen-carrier gas is at a high pressure of up to 0.29 Mpa. The human hair samples were subjected to thermal decomposition treatment (at the temperature of 800 °C) while separated mercury was atomized and then concentrated in a collector tube as a gold amalgam. Afterwards, the mercury collector tube is re-heated, and vaporized mercury is measured by atomic absorption spectrometry. The applied technique does not require any special preparation prior analysis. The detection limit of mercury was 0.002 ng. The correlation coefficient of standard curve equation in each test was at least reach 0.999. The analytical procedure was verified by the analysis of Certified Reference Material of Human Hair NCS DC 73347 from China National Analysis Center. In order to prove the accuracy of this method, CRM was analyzed for hair and the obtained mean value along with standard deviation (0.352 ± 0.020 mg/kg) showed a fair agreement with the certified values (0.360 ± 0.080 mg/kg).

2.3. Statistical methods

The obtained results were elaborated using the Statistica ver.10.0. software. Descriptive statistics such as means, medians, standard deviations, range and 5–95th percentiles were reported. Normality of distribution of experimental results was assessed by Shapiro–Wilk and Lilliefors tests. Data distribution was found non-normal throughout the results. According to non-normal distribution non-parametric methods were applied. The existence of the statically significant differences in the content of mercury in relation to the studied factors was evaluated based on the nonparametric Mann–Whitney U test (significance level $p < 0.05$) and nonparametric ANOVA Kruskal-Wallis test (significance level $p < 0.05$).

3. Results and discussion

Mercury content in hair was determined by Automatic Mercury Analyzer MA 3000. Basic statistical parameters such as mean concentrations along with the relevant standard deviation, median, minimum and maximum values and also the values between 5th And 95th percentile for mercury distribution in human scalp hair from the studied population are reported in Table 1.

In general the average value of mercury content in hair was slightly lower or comparable to the values of populations of large cities in Poland found in the literature data. For example in the paper reported by Michalak et al. (2014) reported that the mean value of Hg in hair of population living in other polish city Wroclaw oscillated around 0.203 ± 0.181 mg/kg. Hair analysis from the population from another big polish city Gdansk located on the Baltic coast showed that the mean values of mercury in hair were about 2 times higher than in our paper. The average mercury content in hair of the inhabitants of Gdansk was at the level of 0.379 ± 0.315 mg/kg (Hać et al., 2000). This fact can

Table 1
Basic statistical parameters for mercury distribution in human scalp hair from the population of people living in the region of Lodz (central Poland) [mg/kg].

Mean	Median	Minimum	Maximum	Percentile-5	Percentile-95	S.D.
0.174	0.143	0.016	1.376	0.045	0.415	0.137