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Monitoring mercury environment pollution through bioaccumulation in meconium

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ABSTRACT

In this study, bioaccumulation of mercury in humans was examined by performing analysis on 165 meconium samples of newborn children in Split and Dalmatian County. Total mercury determination was performed on the Advanced Mercury Analyser AMA 254 without previous sample preparation. Mercury was identified from all examined samples, where mean value of concentration for the whole studied group was 58.19 ng g^{-1}, median 35.69 ng g^{-1} and concentration range from 3.04 to 394.69 ng g^{-1}, respectively. The analysis of the results showed correlation of mercury concentration in meconium with sociodemographic characteristics of the studied group such us living residence place, dietary habits and influence of amalgam fillings. The highest concentrations of mercury were observed in the group in which mothers consumed fish, particularly in the coastal living area. Slightly higher concentrations of mercury in samples were found in the urban living area compared to the rural residence. This was probably due to the strong effect of disposed mercury from the industrial plants into the environment of Split and Dalmatian County during last 50 years. The relation of sea food consumption and mercury content in meconium samples, confirms that food path is responsible for its bioaccumulation and biomagnification from the environment into the living organisms, particularly in humans.

1. Introduction

1.1. Sources of mercury environmental pollution

Environmental pollution is a growing problem affecting all aspects of life. Metals and metalloids are among the most common environmental pollutants. Mercury, considered to be one of the most toxic pollutants is widespread in the environment, more accurately in all spheres of the earth atmosphere, hydrosphere, lithosphere and biosphere. It is present in elemental, inorganic and organic form coming from natural and anthropogenic sources. Mercury in the environment is not biodegradable, has tendency to form organometallic complexes and thereby is biomagnified in organism, particularly in the aquatic food webs of wetlands, rivers estuaries and oceans (Kalisinska et al., 2014; Carrasco et al., 2011). Volcanic eruptions, soil erosion, release from the rocks containing mercury as well as bacterial decomposition of organic mercury compounds are natural sources of mercury emissions into the environment. According to the several surveys 5207 t of mercury are released to the environment on the annual basis from the natural sources. This data includes the primary emission from natural sources, as well as re-emission of previously deposited mercury from anthropogenic and natural sources (Pirrone et al., 2010).

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Anthropogenic sources of mercury are fossil-fuel fired power plants (coal and oil), industrial and municipals sewage treatments, ferrous and non-ferrous metals manufacturing facilities, caustic soda and vinyl chloride production plants, ore processing facilities, incinerators for urban, medical and industrial wastes, cement plants and chemicals production facilities. According to estimations, 2320 tonnes of mercury are emitted annually from different anthropogenic sources (Pirrone et al., 2010). Once entered into the environment, mercury constantly circulates between air, soil and water through the processes of wet and dry deposition, re-emissions and remobilisation. Major source of mercury emission to the air is coal burning, with the majority related to the industry use (Pacyna et al., 2010) while households contribution is negligible. Pig iron and steel production, depending on emission control measures contribute to the mercury emission with 43 tonnes annually (Pirrone et al., 2010; UNEP, 2013). In the cement industry emissions are dependent on the nature of used raw materials and fuels, where conventional coal and oil fuels are often replaced by alternative fuels - different types of waste such as old tires, waste oil, biomass, waste wood and similar, accounting for about 10% in the mercury emission into the air (Pacyna et al., 2006). In majority of chlor alkali plants, mercury cells were used to produce chlorine and sodium hydroxide. From these plants about 163 tonnes of mercury per year can be released to the air, while production of vinyl chloride contributes with 1% of mercury emission in the atmosphere (Pirrone et al., 2010). Another source of mercury emission are disposal of solid industrial, medical and municipal waste, as well as metal smelting industry. Mercury content from these sources depends on the type of waste and treatment processes.

1.2. *Monitoring of mercury environmental pollution in Split and Dalmatian County*

Split and Dalmatian County is the largest County in Croatia, a Mediterranean country located in the south-eastern Europe, bordering the Adriatic Sea. Industrial production was developed including the production of vinyl chloride monomer, chlorine alkali production, pig iron, steel and ferro-alloys factory, galvanisation, cement and shipbuilding industry. Today, many of these productions have broken down and consequences of 50-years long discharge into the environment remained. Metal production is reduced and the remaining industries are cement production and shipbuilding.

The quality of the marine environment in Croatia has been continuously monitored by the Institute of Oceanography and Fisheries, Split, Croatia, through measurement of total mercury concentrations in sediment and mussels Mytilus galloprovincialis. Sampling sites are placed along the Adriatic coast near potential sources of pollution. The summarised results of total mercury concentration in mussels, monitored in the period 2001–2011 are shown in Fig. 1.

Mercury was found in all samples of mussels emphasising that the concentrations were significantly below the 1000 $\mu g\,kg^{-1}$ of wet mass, which is maximum allowable concentration (MAC) according to the European Commission Regulation (EC) No 1881/2006. Exceptions were results from stations p11 and p14, located near sources of inorganic mercury (close to the chlor-alkali plant), measured in the period of 2004–2006. These values were significantly higher compared to MAC (Institute of Oceanography and Fisheries, 2015).

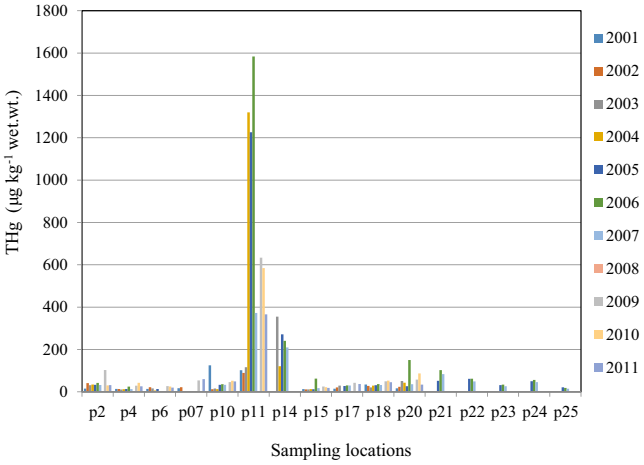

Fig. 1 – Total mercury concentrations measured in mussels (*Mytilus galloprovincialis*) at locations along the Adriatic coast.

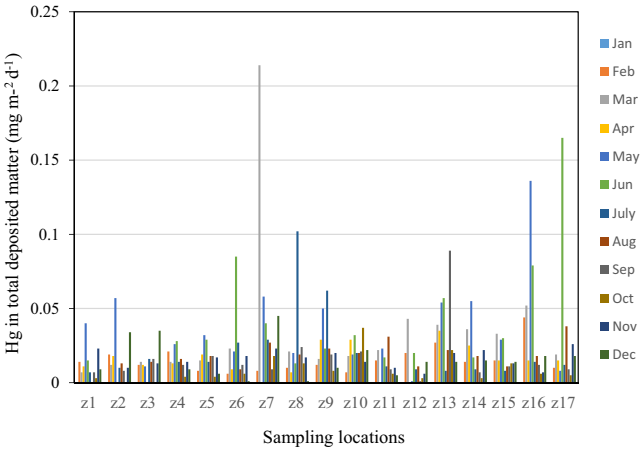

Fig. 2 – Mercury concentrations measured in TDM during 2013 sampled at locations in Split and Dalmatian County.

The largest part of mercury emitted into the air originates from the industrial combustion processes 32.6%, thermal power plants 26.1% and 25.9% from non-industrial furnaces (Croatian Environment Agency, 2013). Monitoring of the mercury concentration in the total deposited matter (TDM) in the Split and Dalmatian County during 2013 year, has shown deposition of mercury from atmosphere to soil, vegetation, water, buildings, etc. The summarised results from Public Health Institute and Croatian Environment Agency are shown in Fig. 2 (Croatian Environment Agency, 2013; Public Health Institute, 2014).

Although the results from all locations are significantly lower than the limited value of 1 $\mu g\,m^{-2}\,d^{-1}$ for mercury content into TDM (Regulation OG 117/12), deposition is permanent and more intensive in the summer period. The results of monitoring mercury concentration in tap water, surface and ground waters was obtained by the Public Health Institute in the period 2001–2011, and were below limit of detection (Štambuk-Giljanović et al., 2012). In the same period mercury concentration was analysed in 124 waste water samples; 63% samples were below limit of detection and 27% ranging from 0.3 to 14.5 $\mu g\,L^{-1}$. In 487 analysed samples of sewage water, mercury was below limit of detection in 71.5% samples, while from 0.3 to 32.7 $\mu g\,L^{-1}$ in the remaining samples. The results of the environmental monitoring given above indicate that the ecosystem of Split and Dalmatian County is