Mercury in *Eisenia fetida* and soil in the vicinity of a natural gas treatment plant in northern Croatia during the last ten years

Prevendar-Crnić A.[1,*], Zgorelec Ž.[2], Srebočan E.[1], Kisić I.[2]

[1]Department of Pharmacology and Toxicology, Faculty of Veterinary Medicine, University of Zagreb, Heinzelova 55, 10000 Zagreb, Croatia

[2]Department of General Agronomy, Faculty of Agriculture, University of Zagreb, Svetosimunska cesta 25, 10000 Zagreb, Croatia

*corresponding author: e-mail: apcrnic@vef.hr

Abstract

In this study total mercury concentrations in earthworms and in different soil types at the same locations from the surroundings of four boreholes were analyzed by ICP-MS method, as a part of a comprehensive monitoring of the eco-system in the vicinity of the natural gas production and treatment plant Molve in northern Croatia. The aim of this study was to determine the concentration of mercury in the collected samples from 2009 to 2019, monitor its changes over a last ten years period and determine the bioaccumulation of total mercury in earthworms from the soil. During the last ten years total mercury concentrations in earthworms (boreholes Molve 9-12) ranged within 0.118 and 0.675µg g_{DW}^{-1} depending on the location and time of sampling, while total mercury concentrations in different soil types at the same locations ranged within 0.020 and 0.515 µg Hg g^{-1} of soil. The calculated mercury bioaccumulation factor ranged between 0.6 and 16.9. Comparing our results with those from the previous research period and also with results published in available literature it can be concluded that investigated area near Molve belongs to low mercury contaminated region.

Keywords: total mercury; bioaccumulation; earthworms; soil quality; natural gas

1. Introduction

Considering the risk of entry of mercury into the environment and food chain, and in order to control and monitor the effectiveness of the closed adsorber system for removing mercury from natural gas installed in 1993, a comprehensive environmental monitoring program was conducted in the gas field Molve (Zgorelec et al., 2009; Špirić et al., 2013). Alongside soil monitoring, we used the earthworm *Eisenia fetida* to assess the transfer of mercury from soil close to the potential sources of mercury pollution. Here we present integrated data on mercury concentrations measured in the tissues of earthworms and different soil types at four locations near the gas field Molve in last ten years in order to compare them with those from the previous monitoring period.

2. Material and Methods

The study area is located within the Koprivničko Križevačka County. During the period from 2009 to 2019, earthworms and soil were sampled in nine occasions. Total Hg in samples were analyzed using inductively coupled plasma - mass spectroscopy. Difference between the locations (Student's t-test) was determined by Statistica 13.4. The bioaccumulation factor (BF) was calculated using the formula: BF = Ce/Cs (Ce – mercury concentration in earthworms; Cs – mercury concentration in soil).

3. Results and Discussion

Total Hg concentrations in earthworm and soil samples at the study locations M9-12 (2009-2019) are presented in Fig. 1, and the average mercury levels and BF for all locations and investigated years are presented in Tab. 1. Results were expressed in µg/g on dry weight basis.

Table 1. The average Hg concentrations with standard deviation (SD) in earthworm and soil samples and bioaccumulation factors (BF) for Hg in earthworms at the study locations M9-12 (2009-2019).

	Molve 9	Molve 10	Molve 11	Molve 12
Earthworm (n = 9) µg Hg/g	0.286 ± 0.09	0.425*± 0.15	0.253 ± 0.06	0.308 ± 0.05
Soil (n = 9) µg Hg/g	0.189 ± 0.08	0.113 ± 0.07	0.099 ± 0.06	0.252 ± 0.13
BF (n = 9)	1.5	3.7	2.6	1.2

* $p < 0,05$

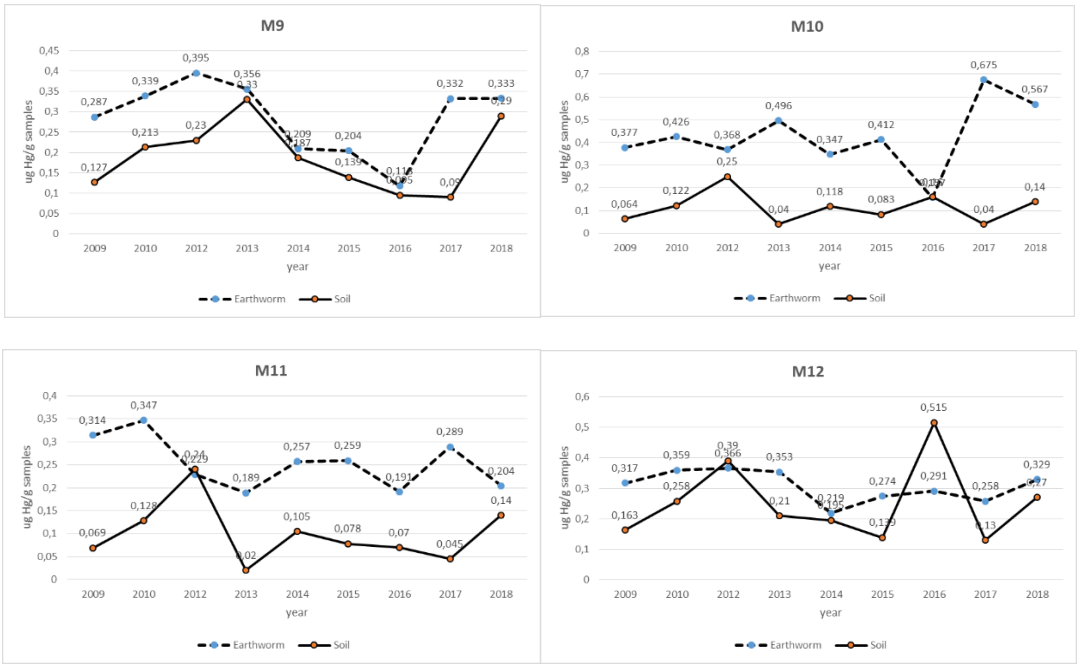

Figure 1. Total Hg concentrations (µg Hg/g) in earthworm and soil samples during investigation period (2009-2019) at the study locations - boreholes Molve 9-12.

The highest measured total Hg concentrations in different soil type from locations M9 - M12 (clay soil, silt loam soil) were 2-4 times lower than the MAC values for agricultural soils (1.0 and 1.5 µg Hg/g). The total Hg in soil at M12 was the highest in comparison with other three borehole locations, but all values are in accordance with those from the Geochemical Atlas of the Republic of Croatia and also with our results from the previous monitoring period (Prevendar Crnić et al., 2016). The mercury levels in earthworm tissue that we measured were slightly lower than those reported previously, but many times lower than those from industrial areas (Hsu et al., 2006). The highest measured total Hg in earthworms was at M10 (Fig. 1), and also the average Hg concentrations at M10 was significantly higher in comparison with other locations (Tab. 1). The BF ranged from 0.6 to 16.9 what is similar to other data reported which suggests that inorganic mercury was abundant in the studied area. In conclusion, during the last ten years monitoring of mercury in the soil in the vicinity of the natural gas production and treatment plant Molve, the reported levels were generally very consistent, below the prescribed MAC for agricultural soils and comparable to findings from studies conducted in uncontaminated areas as well as to our previous results. Results suggest that the mercury removal system of the main plant for gas collection, treatment and purification in Croatia, can be considered effective as the surrounding areas were low in mercury soil and earthworm content and therefore of low risk for human and animal health. Furthermore, obtaining an understanding of the geochemical cycles of mercury is important for the effective prediction and prevention of adverse effects on human health and the environment.

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