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Letters to Editor

Influence of Technological Processes and Improper Storage of Waste on the Mercury Content and Migration in the Soil

B. Gworek, E. Biernacka*

Institute of Soil Science, SGGW, 02-548 Warszawa, ul. Rakowiecka 26/30, Institute of Environmental Protection, 00-548 Warszawa, ul. Krucza 5/11, Poland
* Institute of Recultivation of Natural Environment, SGGW Warszawa
02-787 Warszawa, ul. Nowoursynowska 166

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Abstract

The aim of this work is to examine the abilities of mercury of anthropogenic origin to migrate into the soil profile. The above phenomenon has been evaluated by comparing mercury content in the surface soil layer (0-20 cm) to its content in bedrock (70-100 cm). The studies were carried out on the premises of a plant that applies mercury in the technological processes and has not solved any issues related to waste management.

The studies were situated in the southern outskirts of Warsaw on the premises of a plant that has produced mercury thermometers, areometers, mercury transmitters and some types of laboratory glass for about 50 years. In the close vicinity of the plant there are no other significant sources of pollution.

The present studies prove that 50-year activity of a plant that used mercury in the production processes has contributed to soil pollution by this element. Mercury content in the surface soil layer (0-20 cm) ranged from 1.30 to 940.00, and in the 70-100 cm layer from 1.88 to 412.00 mg•kg^{-1} in soil dry mass.

Keywords: soil, contamination, mercury, migration

Introduction

Mercury can be included in natural circulation in varying intensity. The process consists not only of mercury concentration but also of the form of its occurrence and physical-chemical properties in particular. Mercury pollution of the soil (which is the basic element of the natural environment) is very difficult to remove and long lasting. In soils exposed to local emissions of mercury compounds its content rises continuously and is accumulated mainly in the upper soil layers, where it undergoes chemical, biological and photochemical changes. As a result of microbiological and chemical metilation, mercury compounds change into forms that are easy or difficult to dissolve in water, and hence easier or more difficult to permeate into soil profile [1].

The aim of the present work has been to examine the abilities of mercury of anthropogenic origin to migrate into the soil profile. The above phenomenon have been evaluated by comparing mercury content in the surface soil layer (0-20 cm) to its content in bedrock (70-100 cm). These studies were carried out in the premises of a plant that

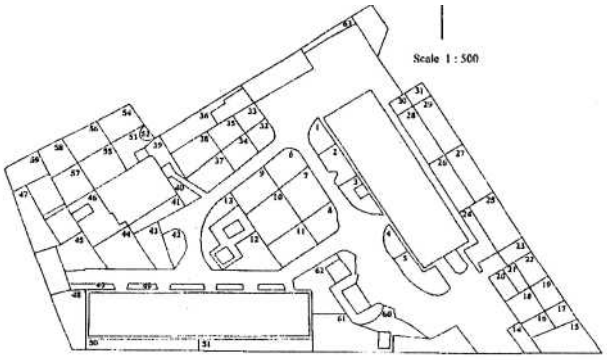

Fig. 1. Situation of study areas.

applies mercury in technological processes and has not solved any issues related to waste management.

Materials and Methods

As stated, our studies were located in the southern outskirts of Warsaw on the premises of a plant that produced mercury products.

The geological structure of this area is not complicated. It consists of quaternary formations of about 60 m thickness that are made of medium fine-grained sands and gravels of fluvioglacial origin that contain sandy loams. The first level of ground waters appears at a depth of 1.5 to 3.5 m (depending on precipitation and ground retention).

The studied area of about 1 ha was divided into 63 study plots taking into consideration infrastructure, tree cover, and areas where waste had been stored (Fig. 1). For the above reasons the areas mentioned above are of differentiated size but are not different in the way they are exploited. They are all covered with grass on which there are several-year-old trees and trees that have been newly planted, mainly coniferous trees (very scarce tree cover). The terrain is flat.

Table 1. Total mercury content in the studied soils ($mg \cdot kg^{-1}$ in dry mass).

No. of study area	Depth cm	Content Hg	No. of study area	Depth cm	Content Hg	No. of study area	Depth cm	Content Hg
1	0 – 20	14.60	24	0 – 20	35.40	45	0 – 20	9.48
2	0 – 20	3.21	25	0 – 20	119.00		70 – 100	53.10
3	0 – 20	14.90	26	0 – 20	21.20	46	0 – 20	33.60
4	0 – 20	252.00	27	0 – 20	12.60		70 – 100	41.30
	70 – 100	92.00	28	0 – 20	3.57	47	0 – 20	10.80
5	0 – 20	12.70	29	0 – 20	1.30		70 – 100	3.38
	70 – 100	24.30	30	0 – 20	940.00	48	0 – 20	5.00
6	0 – 20	12.30		70 – 100	1.88	49	0 – 20	15.40
7	0 – 20	10.90	31	0 – 20	3.49	50	0 – 20	27.10
8	0 – 20	9.88	32	0 – 20	6.16	51	0 – 20	20.40
9	0 – 20	24.50	33	0 – 20	7.93	52	0 – 20	8.27
10	0 – 20	20.00	34	0 – 20	11.90		70 – 100	73.70
11	0 – 20	13.60	35	0 – 20	45.50	53	0 – 20	38.80
	70 – 100	50.30	36	0 – 20	52.40		70 – 100	57.50
12	0 – 20	74.40		70 – 100	164.00	54	0 – 20	20.70
	70 – 100	20.20	37	0 – 20	76.90		70 – 100	69.50
13	0 – 20	65.10		70 – 100	232.00	55	0 – 20	244.00
	70 – 100	10.60	38	0 – 20	57.00		70 – 100	157.00
14	0 – 20	71.80		70 – 100	329.00	56	0 – 20	13.10
15	0 – 20	114.00	39	0 – 20	72.50		70 – 100	20.50
16	0 – 20	14.60		70 – 100	128.00	57	0 – 20	48.40
17	0 – 20	233.00	40	0 – 20	80.10		70 – 100	28.60
18	0 – 20	222.00		70 – 100	15.60	58	0 – 20	28.70
	70 – 100	57.10	41	0 – 20	152.00		70 – 100	32.10
19	0 – 20	156.00		70 – 100	65.00	59	0 – 20	10.50
	70 – 100	23.20	42	0 – 20	237.00	60	0 – 20	17.00
20	0 – 20	115.00		70 – 100	10.20		70 – 100	36.70
21	0 – 20	153.00	43	0 – 20	70.70	61	0 – 20	10.40
	70 – 100	36.30		70 – 100	7.10	62	0 – 20	9.12
22	0 – 20	151.00	44	0 – 20	129.00		70 – 100	3.76
	70 – 100	20.60		70 – 100	128.00	63	0 – 20	176.00
23	0 – 20	260.00					70 – 100	412.00

A mixed average soil sample was picked up for the present analysis from each of the studied areas. The samples should reflect the state of actual soil pollution.

Soil material was taken for analysis from two different depths, i.e. 0-20 cm and 70-100 cm in order to assess the abilities of mercury compounds to migrate into the soil profile. The samples taken from the depth of 0-20 cm were taken from all the study areas, whereas from the depth of 70-100 cm from 32 study areas only. The soil material was then dried at a temperature of 20°C. After all the particles larger than 1 mm had been sieved out, mercury content was determined by means of hydrides applying the technology of atomic sorption spectrophotometry. Statistical error of the method in case of reference samples fluctuated within the limits of 3.7-6.8 %.

Study Results and Discussion

Total mercury content is presented in Table 1. In the upper layer of the studied soils (0-20 cm) mercury content ranged from 1.3 to 940.0 $mg \cdot kg^{-1}$ of soil dry mass, and in the 7-100 cm layer it ranged from 1.88 to 412 $mg \cdot kg^{-1}$ of soil dry mass. The level of 0.1 $mg \cdot kg^{-1}$ of mercury in soil dry mass is considered the natural mean mercury level and in the sandy soils this level is 0.04 $mg \cdot kg^{-1}$ of the soil dry mass [2]. Mercury levels found in the soil of the study area clearly showed that it was polluted. Especially high mercury accumulation was noted in the closest neighbourhood of the building where mercury is used on the production line and in the waste removal areas (36, 38, 39, 44-46, 52, 57, 63). Moreover, in some of the studied areas (e.g. 36, 39, 63) mercury content in the 70-100 cm layer is higher than in the surface layer. This condition results from the fact that surface soil layer taken off the areas adjacent to the factory was stored in areas with lower mercury content.

Mercury both in the ionic and gaseous forms in the soil environment undergoes sorption by organic, mineral, and loamy substances, mainly montmorillonites [1, 3]. Kostaal. [4] and Lockeretz [5] found out that despite the fact that mercury appears in bound form, its compounds are easily soluble and undergo migration into the soil profile.

In the analyzed soils there were especially favourable conditions for mercury migration into deeper layers. In the surface layer of the analyzed soils the content of organic substances is scare and ranged from 0.4 to 0.9%. Moreover, granulometric composition of these soils (loose sand) pointed to the lack of minerals that could contribute to binding of this element. Mercury accumulation in the 70-100 cm soil layer proves its ability for quick movement deeper into the soil profile. In the studied area the above process has been taking place for about 50 years.

Similarly, McLean et al. [6] found migration of mercury with anthropogenic origin into the soil profile. However, the depths were considerably smaller.

Summary

1. The present studies proved that 50-year activity of a plant that used mercury in production processes contribu ted to soil pollution with this element. Mercury content in the surface soil layer (0-20 cm) ranged from 1.30 to 940.00 and in the 70-100 cm layer from 1.88 to 412.00 $mg \cdot kg^{-1}$ in the soil dry mass.

2. On the basis of the mercury levels in the 70-100 cm soil layer it can be said that in the sandy soil mercury of anthropogenic origin migrates very quickly into the soil profile. The above processes create a very serious risk of pollution of ground water. Moreover, areas polluted with the discussed element become a source for new secondary pollution.

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