Environment Protection Engineering

Vol. 4 1978 No. 2

COMMUNICATION

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APPLICATION OF MERCURY IN AGRICULTURE, AND THE QUALITY OF SURFACE WATERS

1. INTRODUCTION

Mercury, as a natural component of some minerals is found in soil, water, atmosphere and living organisms. Human activity, which contributes essentially to the increase in the content of this component in the environment, should be considered a hazard for biosphere, because of its high toxicity, stability and cummulative properties. There are many sources of environment pollution with mercury, the main of which are:

- electrolytic production of chlorine — 42%,
- combustion processes of hard coal and petroleum (crude oil) — 30%,
- chemicals, reagents and pharmaceutics as well as metallic mercury in the apparatus used in industry and research — 21%,
- plant pesticides — 7%.

As it follows from the list given above, electrolytic processes, and the combustion of hard coal and petroleum are the most important sources of surface water pollution with mercury. The first source gives a direct pollution of water with industrial wastes, while the second one causes an indirect pollution through the atmosphere. Application of plant pesticides containing mercury only slightly contributes to the total mercury pollution in this country. From the investigations carried out in the United States for 15 years in the case when mercury fungicides were applied each year, it follows that mercury is accumulated in the surface layer of soil, and shows no tendency to be displaced [11]. Investigations conducted in the Soviet Union have also shown that even a 20 year application of mercury compounds to seed dressing does not create any significant source of pollution [6]. In Polish literature, however, there are no data allowing to state whether and to what degree the sowing seed dressing with mercury fungicides contributes to the pollution of surface water.

The investigations on the effect of organic mercury fungicides on the quality of surface waters have been performed in the Institute of Meteorology and Water Management in Gdańsk, in the years 1974–1975. This problem has been solved by comparing the level of mercury in water bodies catchment areas utilized in agriculture and in water bodies having catchment areas without any contact with agriculture. Mercury compounds penetrating into undergo a two-directional microbial conversion. Some bacteria are responsible for mineralization of organic compounds, the others cause methylation of inorganic compounds to the methylmercury or dimethylmercury [15]. Under such circumstances, and considering the fact that the

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detectability of the so far used analytical methods is much limited, the content of the active substances of organic mercury fungicides in water cannot be practically determined.

The results obtained, apart from the answer to the question stated before, gave the first recognition of the mercury level in the inland surface waters in this country.

2. METHODS

Five lakes of Kaszuby and four irrigation canals in Żuławy area have been selected as the objects to be examined [15]. In the selected water basins there were no point pollution sources. The catchment areas of three lakes as the area drained by three of the selected irrigation canals were used for agricultural purposes. In the period of investigations and in the previous years fungicides with mercury contents ranging from 0.8 to 2.5 % were used in doses of 200–300 g per 100 kg of the average sowing seed.

In the given farming area the frequency of the dressed seed used amounted to 2.5–3 years, according to recommendations of crop rotation. The two remaining lakes with typical forest catchment areas had no contact with agriculture. There was neither any possibility for mercuric pesticides to penetrate into the last of the selected irrigation canals, which along its whole length adjoined grasslands.

Taking account of the cummulative properties of mercury the pollution degree of the selected water basins was evaluated by determining the mercury content in water, bottom sediment and fishes.

The investigations were performed over the entire annual cycle. Water for chemical analyses was sampled once a month from various levels of the deepest parts of lakes and at different points of irrigation canals. The series of bottom sediment samples were taken in the same sites. Fishes (roach, perch, bream) were once fished out from the separate lakes taking for analysis the individuals of the same age. Mercury content in the material examined was determined by flameless atom-absorption spectrophotometry using an analyser of the type MAS-50 produced by Coleman. The concentration of inorganic and total mercury in water was determined after the sample was settled. Mineralization on cooling was conducted according to BRANDENBURGER [3]. Bottom sediments and fish tissus were mineralized on heating by using the methods of BRANDERBERGER [3] and JEFFUS [9], respectively.

The results were analyzed statistically by using Student's test to estimate the significance of the difference between two normal means (the method of non-matched pairs) [12].

3. DISCUSSION OF RESULTS

Water of the selected lakes was characterized by a low salinity (mean value of dry matter 62–342 mg/dm^3, mean value of chlorides 7.2–27.2 mg/dm^3), its pH was 6.3–7.7 and hardness ranging within 0.26–4.14 mval/dm^3. Permanganate value ranging from 4 to 9 mg/dm^3 O_2 indicated that the loading with organic substances [14] was not great.

The concentration of mercury was influenced neither with seasonal stratification of the water in lakes, nor with sampling time. Hence, the analysis of the results obtained was based on the mean concentrations of mercury in water.

In lakes with catchment areas utilized in agriculture, the total mercury content varied from 0.34–1.80 μg/dm^3, the average amouned to 0.88 μg/dm^3 and resembled the averages of individual reservoirs. Forest lakes were characterized by a similar content of mercury in water (0.36–1.46 μg/dm^3 on the average 0.86 μg/dm^3). According to expectations, statistical tests (probability level 95 %) have shown that the difference in mercury content between the two groups of lakes is not significant, even in case when the lakes analyzed were characterized by the highest differences in mercury content. In all the cases the ratio of the mineral mercury to the total mercury content in water was similar, i.e. equal to about 1 : 3.

Water in irrigation canals differed from that in lakes, being characterized by high and varying salinity, typical for all the surface waters in Żuławy. Dry matter varied from 752 to 5,312 mg/dm^3, content of chlorides ranged within 160–2344 mg/dm^3, and hardness from 4.65 to 19.10 mval/dm^3 [14]. This water was characterized, moreover, by a high content of organic substances (the average permanganate value 12.65–

15.31 mg/dm^3). In spite of these facts the average of total mercury concentration in water was similar to that found in water of lakes and it varied from 0.25 to 1.28 μg/dm^3 — 0.73 on the average. The mean mercury concentration in a canal situated on meadows was somewhat lower than in canals being in a direct contact with corn fields (0.63 μg/dm^3 and 0.77 μg/dm^3, respectively). For the obtained dispersion of the result values the difference between the means was not significant statistically. The ratio of mineral mercury to the total mercury content was also the same and amounted to about 1:2.5 being thus somewhat higher than in lakes, probably due to the character of water in irrigation canals.

The level of mercury pollution found in the examined surface waters did not differ from the average value found in world literature. According to the data found in the Western literature the concentration of mercury in such reservoirs reaches 0.6 μg/dm^3 [1, 4, 8, 10, 16], while in waters of North Ukraine the mercury content is of the order of several micrograms in one dm^3 [2].

Mercury content in sediments uses taken from the lakes with the water catchment area utilized in agriculture varied from 0.14 to 0.38 mg/kg of dry weight of the sediment, on the average — 0.21 mg/kg [14]. Similar level of mercury has been stated in sediments in one of the forest lakes (0.15 to 0.27 mg/kg, on the average — 0.20 mg/kg). In the second lake with the catchment area not utilized in agriculture, the contents of mercury determined in the sediments was much higher (varying from 0.64 to 1.74 mg/kg — on the average 1.18 mg/kg). In this lake water, and sediment chemistry also differed, however, from that stated in the remaining lakes (low hardness as well as the concentrations of the substance dissolved in water, and very high content of organic carbon in the sediments (16.0–22.8 %). Higher concentrations of mercury found in the sediments of this lake can be explained by high content of carbon, because of the correlation between the two elements in the sediment, stated in the literature [11].

The average content of mercury in the sediments of the canal localized on meadows was not lower than that in canals adhering the cultivated fields (0.122 and 0.76, 0.127 and 0.076 mg/kg, respectively) [14].

The level of mercury found in sediments of the reservoirs examined didn't exceed the values quoted by various authors in the world literature [1, 8, 13].

Mercury content in fishes did not differ from the average data for the reservoirs not polluted artificially with mercury reported in the world literature ealier. In the forest lakes as well as in the lakes with the catchment area utilized in agriculture, the fishes contained similar residues of mercury not exceeding 0.58 mg/kg of the whole body, on the average 0.29 mg/kg [14].

4. CONCLUSIONS

Investigations performed in the Institute of Meteorology and Water Management in the years 1974–1975 did not show detectable effect of mercury fungicides applied in agriculture on the pollution of surface waters with mercury. The levels of mercury in two different types of water reservoirs: with catchment areas utilized and not utilized in agriculture, both in water, bottom sediment, and in fishes were similar. The ratio of mineral mercury to the total mercury was also similar.

Considering the fact that mercury does not show any migration tendency in the soil, there is a little probability that its penetration to surface waters should be considered a hazard.

Mercury concentrations in water, bottom sediments and fishes did not differ from the average level quoted in the world literature for such kind of water bodies

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