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MERCURY LEVEL IN FEATHERS OF SPARROWS FROM INDUSTRIAL AND NONINDUSTRIAL AREAS OF LOWER SILESIA, POLAND: TOWARD A NON-DESTRUCTIVE BIOINDICATOR OF ENVIRONMENTAL POLLUTION

Concentration of mercury in feathers collected from sparrows caught in the nets in industrial and nonindustrial regions of Lower Silesia, Poland, was determined. Statistically relevant differences were shown for the content of mercury in feathers from industrial and nonindustrial areas. Average contents of mercury in industrial and nonindustrial areas were 2.0 and 1.3 mg/kg of dry weight, respectively. Maximum content of mercury in feathers from nonindustrial region was not higher than 2.05 mg/kg, while in the industrial areas the percentage of samples containing mercury in concentration above 2.1 mg/kg reached 40%. This preliminary research confirms the assumption that feathers of non-migratory birds may reflect the level of contamination of environment in the spot investigated.

1. INTRODUCTION

With the progress in technology and with rapid industrial development the content of different toxic substances (i.e. heavy metals) in environment has increased considerably in the past few decades. Although the natural systems are able to adopt and buffer large doses of these excessive wastes, there is an urgent need to control and monitor the level of contamination.

The metals that enter ecosystems can originate from natural processes as well as from anthropogenic activities such as agricultural run off, industrial effluent or transportation leakage [1]. Since metals accumulate in animal tissues and organs at the levels considerably higher than in the physical environment, biological monitoring using different types of animals has been widely tested and described in the literature [2]–[5].

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Birds, commonly recommended as the indicators of environmental pollution, may accumulate heavy metals originating from the external sources, from their own feathers during their preening or from contaminated food and water. Elements uptaken by animals may be either accumulated in their tissues or metabolised and excreted from their organisms into environment. Offering non-destructive sampling possibilities and permitting temporal studies, bird feathers seem to be a particularly convenient material for monitoring the pollution of ecosystems by toxic elements, especially by mercury.

Mercury occurs naturally in several forms with quite different biological impact and accumulates at each stage of each food chain. As shown in the literature, mercury which is excreted from a bird body and partly remains on its feathers is in an organic methylmercury form, while this causing surface contamination is mostly in inorganic form. Although it is possible to separate biochemically methylmercury from inorganic mercury, which originates from external sources and adheres to the feather surface [6], only the measurement of total mercury content allows us to assess its entire anthropogenic impact on the surroundings.

2. MATERIALS AND METHODS

The mercury content in sparrow feathers (*Passer domesticus*) collected from two differently polluted areas in the Lower Silesia region, Poland, was investigated. The first area was located within walking distance of the village Siechnice, some 20 km of Wrocław (capital of the Lower Silesia region, population over 700 000). Netting took place ca. 500 m around the Czechnica Power Station and at the former yards of recently closed metal mill Czechnica. The other area was located near Milicz, a relatively unpolluted agricultural land where the exposure to anthropogenic mercury can be assumed as negligible. Birds were trapped by mist-nets and were released immediately after feathers plucking (a few only). Feathers were stored in the labelled polyethylene bags. In order to achieve a total, endogeneous and exogeneous mercury concentration, no washing procedures were applied before analysis. Homogenised feathers' samples (ca. 20–50 mg) were analysed by AAS AMA 254 without any further pre-treatment. Detection limit was $2 \cdot 10^{-4}$ mg/kg.

The accuracy of the analytical methods was better than 10%.

3. RESULTS AND DISCUSSION

The results of the analysis are given in table 1 and compared with the results obtained for feathers of other passerines from southern Finland (table 2). The analysis proves that the mercury concentrations in feathers collected from unpolluted and polluted areas differ significantly ($P > 95\%$). The maximum content of mercury in the feathers from nonindustrial region was 2.05 mg/kg, while in the case of industrial areas, the percentage of samples containing mercury in concentration above 2.1 mg/kg

reaches 40%. The figure shows the distribution of the content of mercury in the sparrow feathers from industrial and non-industrial areas. The difference in the content of mercury observed in sparrow feathers from the two areas may reflect different levels of their contamination by mercury. Significantly higher level of mercury in the feathers of birds from Siechnica was likely caused by high-power and dust coal-fired power station, and by coal-fired stoves and ovens in the private houses in two villages nearby. Last but not least reason of higher contamination of the Siechnica region could be the transportation pollution.

Table 1

Mercury concentration (mg/kg, d.w.) in the sparrow feathers
from Siechnice and Milicz, Lower Silesia, Poland

Location	<i>n</i>	<i>x</i>	SD	<i>R</i>
Siechnice	53	1.94	0.35	0.62–4.31
Milicz	35	1.30	0.12	0.71–2.05

n – total number of samples, *x* – mean value, SD – standard deviation, *R* – range.

Since sparrows and the other passerines occupy a low trophic level, mercury content in their organisms being highly determined by their diet directly reflects the contamination of environment. It was also found that the grain-eating birds are less contaminated than the predators killing them [7].

Table 2

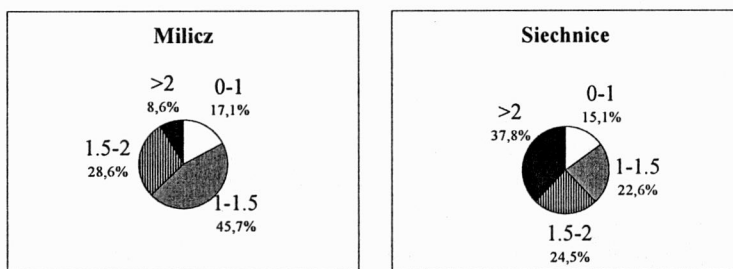
Mercury concentration (mg/kg, d.w.) in the passerine feathers
from southern Finland [7]

Species	<i>n</i>	<i>x</i>	<i>R</i>
<i>Fringilla coelebs</i>	5	2.5	0.8–4.2
<i>Parus montanus</i>	3	2.2	1.3–2.7
<i>Parus major</i>	3	0.7	0.5–0.8
<i>Sturnus vulgaris</i>	2	1.0	0.6–1.4

It is interesting that content of mercury in the aquatic food webs is markedly higher than in terrestrial ones [8].

It is a well-known fact that birds accumulate heavy metals originating both from the ingested food and from living environment. Moreover, their natural nutrient level represents the balance between the rate of intake and elimination [1]. Once a metal enters the body it can be stored and accumulated in such tissues as: liver, kidneys, fat, bone, muscles, or it can be eliminated from the body with excreta during the feather or egg formation [9].

The level of metals in feathers reflects the body burden and the blood circulation level at the time of feather formation [1]. At the time of feather growth toxic substances in the blood are delivered to the feathers, and those having the affinity for the keratin sulfuryl groups are deposited in the feather structure. Many studies proved, for example, that mercury is incorporated into feather by the firm bonding to the disulphide bounds of the keratin [6], [10]–[12] and even a vigorous washing treatment may not affect it.



Distribution of mercury concentration (in mg/kg dry weight) in the samples from Milicz and Siechnice regions

Once the feather is fully formed the blood and nervous connections are cut off and only the external deposition may increase its metal concentration. The physiologically separated feather remains in the skin for approximately 6 to 12 months, depending on the moult frequency for the particular feather tract [1]. This reminds the situation of *Cervidae* antlers, which being dropped and built up once a year can be recognised as a non-destructive bioindicator [5].

APPELQUIST [13] found that the mercury content in the birds' feathers, liver and kidneys is more or less constant and makes the ratios 7:3:1. That relation allows the assessment of the contamination of different tissues or organs of the bird body.

It is well established that the level of mercury in organisms of young birds is distinctly lower than for adults, for which the mercury content in feathers is not correlated with their age. On the other hand, it depends strongly on the gender of individuals; females manifest relatively lower level of heavy metals in their organisms due to "cleansing process" during eggs' laying. The only way of removing trace metals from the male organism is moulting.

These facts may explain a relatively wide range (*R*) of the results obtained because the samples were collected statistically without correlation with age or gender.

4. CONCLUSIONS

The results obtained confirm the widely-known opinion that the feathers of non-migratory birds can be used as non-destructive bioindicators of contamination of local environment. Because of the character of the specimen, in feather analysis, endangered

species as well as dead animals and museum bird skins may be repeatedly examined, which gives the opportunity for examination of historical changes [1], [13]–[15].

The elevated level of contamination of environment by mercury can arise from intensive burning of the fossil fuels, and especially of the coal.

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POZIOM RTĘCI W PIÓRACH WRÓBLI Z UPRZEMYSŁOWIONYCH
I NIEUPRZEMYSŁOWIONYCH TERENÓW DOLNEGO ŚLĄSKA: W POSZUKIWANIU
NIEDESTRUKCYJNEGO (PRZEŻYCIOWEGO) WSKAŹNIKA SKAŻENIA ŚRODOWISKA

Zmierzono zawartość rtęci w piórach wróbli złapanych w sieci w dwóch rejonach Dolnego Śląska: w okolicy Milicza i w bliskim sąsiedztwie elektrociepłowni Siechnice. Dają się zauważyć statystycznie istotne różnice w zawartości rtęci w piórach wróbli pochodzących z obu terenów. Średnia zawartość rtęci w piórach ptaków z okolic Siechnic wynosiła 2,0 mg/kg suchej masy, a z okolic Milicza – 1,3 mg/kg suchej masy. Maksymalna zawartość rtęci w piórach wróbli z okolic Milicza nie przekraczała 2,05 mg/kg suchej masy, podczas gdy aż 40% próbek z okolic Siechnic zawierało więcej rtęci niż 2,1 mg/kg suchej masy. Przeprowadzone badania potwierdzają tezę, że pióra nie migrujących ptaków odzwierciedlają lokalny poziom zanieczyszczenia środowiska naturalnego.