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# PATHWAYS OF HEAVY METALS IN COMPONENTS OF A FOREST ECOSYSTEM

## PREFACE

Intensive industrial growth has always entailed deterioration in the natural environment and hence almost everywhere in the world some activities aimed at halting the build-up of these adverse effects have been pursued. High levels of extremely harmful toxic emissions into the atmosphere (chiefly those from metallurgic and energy industries) bring about inadvertent changes in the environment. Their deleterious effects manifest themselves in contamination of soils (acidification, accumulation of heavy metals, suppressing the decomposition of organic matter), of water, field crops, and in destruction of vegetation and wildlife. Ever increasing levels of pollution adversely affect forest management (disturbing forest ecosystems), agriculture (declining output), and health of the population in large urban areas situated close-to the industrial centres.

The forest ecosystems, particularly coniferous ones, have been always susceptible to the adverse effects of industrial emissions. Even if the level of emission remains stable the effects of some harmful factors (e.g., heavy metals) will build up owing to the tendency of some components of pollution to accumulate (Smith 1981, Zieliński 1984). In recent years, these particularly endangered coniferous forests have attracted a number of comprehensive ecological projects almost everywhere in Europe and in industrialized regions of the United States and Canada alike (Ellenberg 1971, Likens et al. 1977, Persson 1980, Smith 1981, Grodziński et al. 1984).

Niepołomice Forest (11000 hectares), situated in Southern Poland 20 km east of the town of Cracow and the Lenin steelworks, has remained for more than 30 years under uninterrupted pressure of industrial emissions (Grodziński and Yorks 1981). The emissions come from both the local sources (eleven large industrial plants) and more distant ones (Upper Silesia industrial region). Mean annual dust fallout on Niepołomice Forest amounts to 59 $t \cdot km^{-2}$. During an average year every square

kilometre of the Niepołomice Forest receives about 3 t of Fe, 125 kg of Zn, 31 kg of Pb, 18 kg of Cu, 6 kg of Ni, and 1.5 kg of Cd. About 45% of this amount represent the soluble components (i.e., those posing the gravest danger to living things). The annual sulphur fallout value stands at 6 $t \cdot km^{-2}$ (M a n e c k i 1984).

In the 1976–1980 period, studies on the functioning of the Niepołomice forest complex had been carried out. Gaseous and dust industrial emissions (sulphur and heavy metals) were quantitatively assessed; the corresponding levels of these pollutants in soil, water, and forest litter were also studied. The concentrations of heavy metals in selected plant and animal species in the area were also determined. Biogeochemical cycles of principal nutrients and pollutants were described for both coniferous and deciduous forest complexes in Niepołomice Forest (G r o d z i ń s k i et al. 1984).

The studies pertaining to the levels of heavy metals in bodies of plants and animals represented typical bioindication-oriented approach that could only indicate whether given area was contaminated or not, and allowed no more than rough estimates of the pollution levels. Bioindications as such could not suffice for more detailed assessment of how pollution might affect particular links in trophic chains nor could it provide any basis for forecasts pertaining to whole ecosystems. The logical next step in a comprehensive approach should thus include ecophysiological studies bordering on toxicology.

The results of the studies carried out so far have yielded much information about current concentrations and various degrees of accumulation of heavy metals in various organisms living in the same ecosystem. These depend on an array of factors, such as species, age, physical shape, nature of food and feeding habits, etc. Most of organisms can somewhat adapt to the adverse environmental conditions, can eliminate surplus of the metal out of the body and, finally, can use efficient de-toxifying mechanisms at the molecular level. Nevertheless, all the above protective mechanisms have limited capacity and may fail above certain levels of heavy metals in the environment.

It is not known yet how large quantities of the heavy metals may enter organisms from the environment and to what extent they may be tolerated without increase in mortality affecting, in turn, the population numbers. It is just the juncture where the rationale behind attempting of the seemingly pure physiological studies becomes apparent. Many phenomena occurring in response to the presence of heavy metals in the environment cannot be ultimately explained without applying methods of investigation used in overlapping areas of physiology and toxicology. The complicated nature of heavy metal effects in living organisms calls for a wide knowledge of biochemical processes as well. The toxicity of heavy metals do not stop at simple accumulation in tissues – there are multiple effects that take place at the molecular level.

The collection of papers presented in this volume focuses on the effect of pollution on Niepołomice Forest and represent a continuation of the previous comprehensive effort undertaken in the same area (G r o d z i ń s k i et al. 1984). The studies carried out in 1980–1985 period under the grant MR II/15 and co-ordineted by the Institute

of Ecology, Polish Academy of Sciences, Dziekanów Leśny n. Warsaw aimed at explaining complicated mechanisms that determine actual levels of heavy metals in plants and animals. Only a limited number of species could have been covered by the study; they nevertheless represented various components of ecosystems within Niepołomice Forest. It was necessary to survey the lot of organisms living there and thus such groups as microorganisms of surface and ground waters of the forest, as well as the epigeic fauna of the pine forest (dominating in the forest stands at Niepołomice) were included in the project. In order to assess the overall toxic effects of heavy metals present in various toxic dusts, a large field project was designed in which increasing amounts of fallout were simulated in field conditions.

The concentrations of heavy metals in the bodies of rodents and in bodies of some other organisms forming short food chains, reflect overall levels of accumulation that may occur in plants and animals living for some time in the polluted environment. These studies are followed by a series of papers reporting typically experimental attempts to explain mechanisms of the effect of exposure to heavy metals. These employed both laboratory animals (*Mus musculus* L.) and bank voles – a rodent species dominating in Niepołomice Forest.

Any attempt to determine level of pollution in a given area requires a relatively unpolluted control area to compare with. Within Europe, Poland being no exception, there is virtually no unpolluted site to be seriously thought of as a "clean" region. The nearest relatively unpolluted area: Babia Góra National Park situated in about 100 km distance from Niepołomice Forest was thus considered a viable option. Two papers from there provided data on the chemistry of atmospheric precipitation and the accumulation of heavy metals in leaves of some tree species. Yet another facet of the changes taking place in relatively "clean" areas is described in paper on mass outbreaks of phyllophagous insects in some national parks.

The collection of papers presented in this volume constitute a limited attempt to follow pathways of heavy metals in a forest ecosystem permanently affected by industrial air pollution under the conditions prevailing in Southern Poland.

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