DOI: 10.2478/cdem-2022-0006 CHEM DIDACT ECOL METROL. 2022;27(1-2):53-78

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THE BIOLOGICAL MONITORING AS A SOURCE OF INFORMATION ON ENVIRONMENTAL POLLUTION WITH HEAVY METALS

Abstract: The influence of environmental pollution on living organisms has been known for a long time, but it was not until the second half of the twentieth century that methodical studies on the influence of anthropopressure on changes in ecosystems began. Living organisms began to be used as biological indicators of environmental pollution. Cyclical and quantitative studies of pollutant concentrations in bioaccumulators have become the basis of modern biological monitoring (biomonitoring) of environmental pollution. Biomonitoring studies are carried out with the passive method (passive biomonitoring), in which living organisms occurring in their natural environment are analysed, and with active methods (active biomonitoring), in which, for example, plants living in the environment with low pollution are transferred and displayed in more polluted ecosystems e.g. heavy metals. The analysis of trace elements, including heavy metals accumulated in algae, mosses and lichens used in biological monitoring provides a lot of information on, among others concentration and origin of pollutants and the directions of their spread. Biomonitoring is used to assess the level of contamination of selected ecosystems, as well as the impact of individual emitters on the environment. An important element in determining the concentrations of trace elements in biological material used in biomonitoring is the proper planning of the experiment, taking into account, among others: methods of collecting or exposing samples, selection of analytical methods and methods of evaluation and interpretation of results. The aim of the presented long-term research, conducted by the Research Team of the Institute of Biology of the University of Opole, was to show that analytical techniques using biota samples can provide reliable data on the past, present and future state of the environment. However, it should be remembered that in order for the results of biomonitoring studies to be reliable and comparable, the applied research methodologies should be consistent and repeatable. In the presented research, *Palmaria palmata* and *Spirogyra* sp. algae, *Pleurozium schreberi* mosses, *Hypogymnia physodes* and bark of deciduous trees were used. In samples of biological material by the method of atomic absorption spectrometry, the concentrations of heavy metals, including Ni, Cu, Zn, Cd and Pb, were determined. On the basis of the conducted research, it was unequivocally stated that the biomonitoring methods are a good complement to the classic methods of environmental quality assessment. The analysis of the elements accumulated in the biological material provides us with information about the quality of the examined ecosystems, the introduced pollutants and their potential sources. This information allows for the introduction of effective measures to improve the quality of the environment.

Keywords: biological monitoring, biomonitoring, biological material, heavy metals, atomic absorption spectrometry

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THE BIOLOGICAL MONITORING AS A SOURCE OF INFORMATION ON ENVIRONMENTAL POLLUTION WITH HEAVY METALS

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„Currently, **bioindication methods** are beginning to effectively compete with traditional methods of testing environmental pollution and are becoming one of the pillars of modern environmental monitoring” [1, 2].

2

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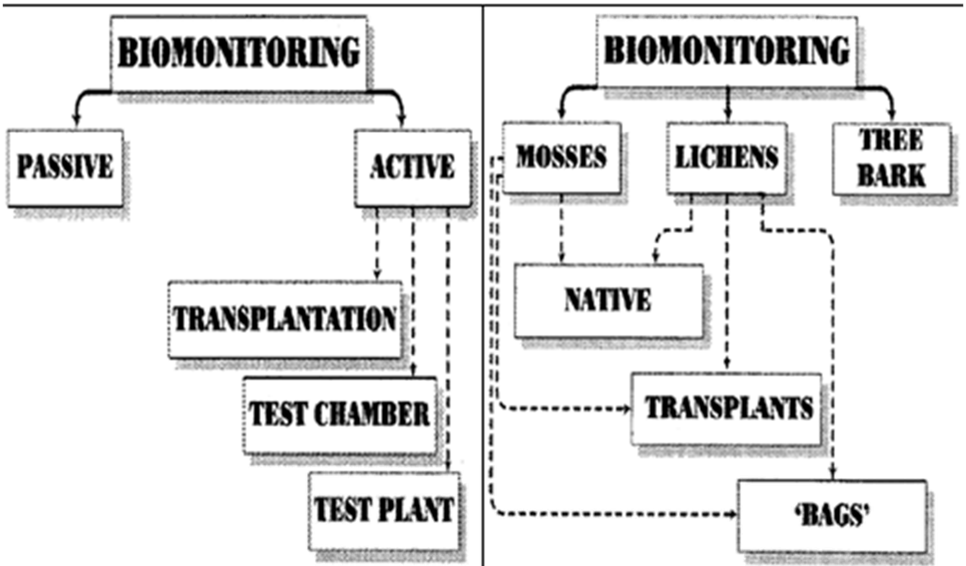
Division of biomonitoring methods [3]



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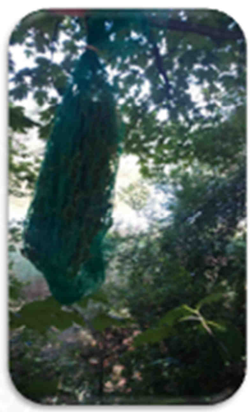
Passive biomonitoring

In passive biomonitoring, biota samples taken from their natural environment are subjected to analysis [4, 5].

Active biomonitoring



The *moss-bag* method assumes the placement of a biosorbent in plastic mesh and exposure for a defined period of time at a selected location. The assessment of the level of contamination is estimated based on the increase in concentrations of analytes after a specified period of exposure [6-9].

4

The criteria to be met by bioindicators [10]:

- widely available at any time of the year
- relatively large tolerance in relation to tested analytes
- the possibility of linking deposition with the content of analytes in biota elements
- relatively cheap sampling
- no need to apply for special permits for common species
- no need for specialised training

5

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Main research topics implemented in air biomonitoring [11, 12]:

- **assessment of pollution of the studied areas**
- **directions of spread of pollution**
- **origin of impurities**
- **comparative study**

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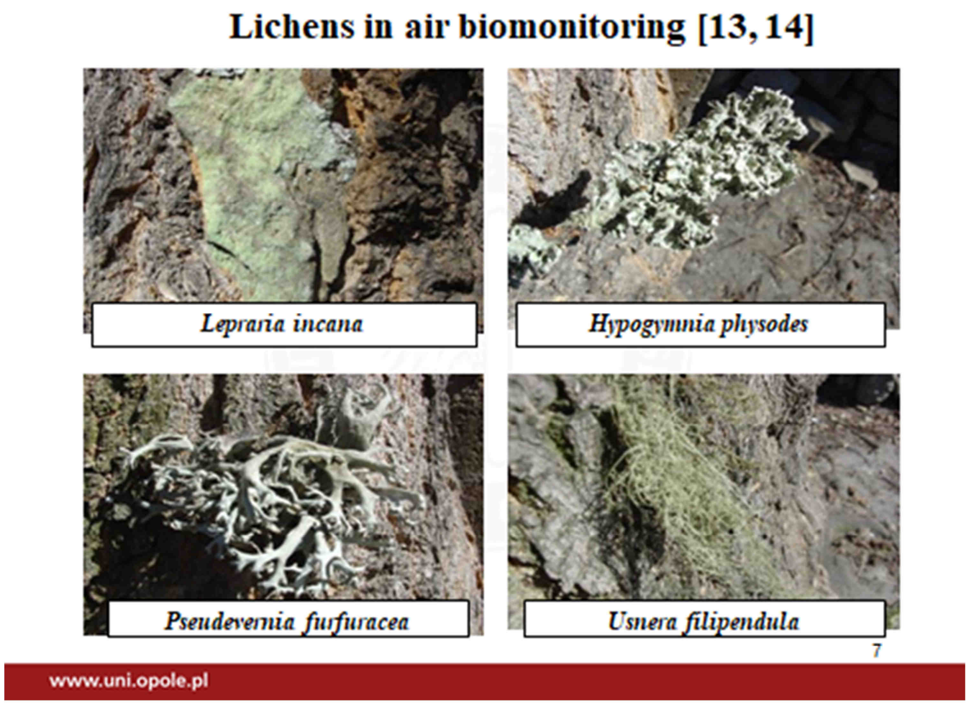
Lichens in air biomonitoring [13, 14]
Lepraria incana
Hypogymnia physodes
Pseudevernia furfuracea
Usnera filipendula
7
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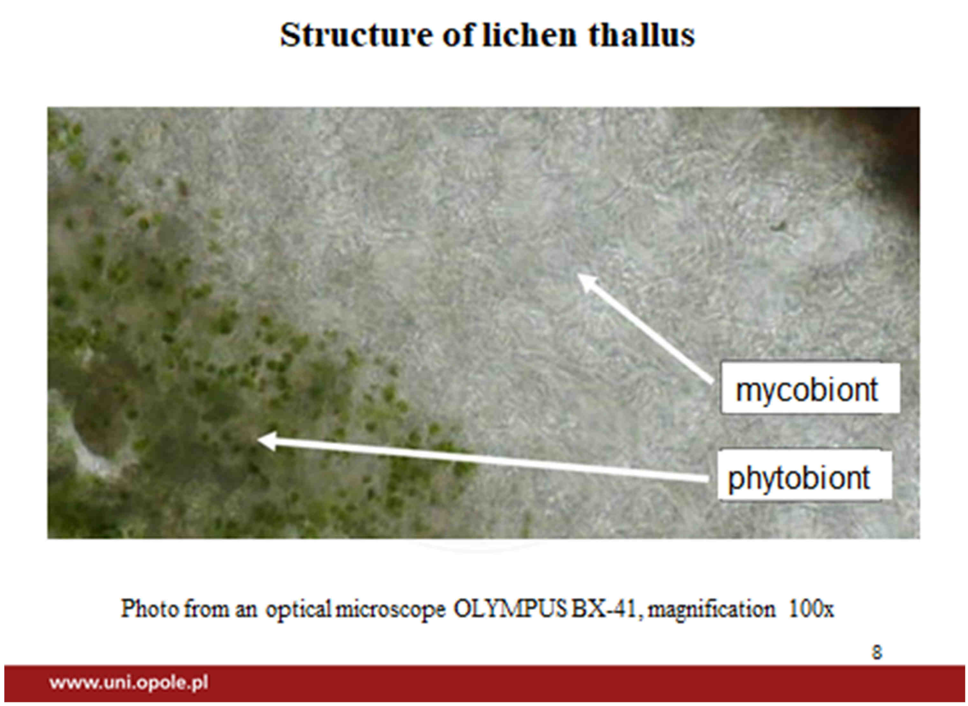
Structure of lichen thallus
mycobiont
phytobiont
Photo from an optical microscope OLYMPUS BX-41, magnification 100x
8
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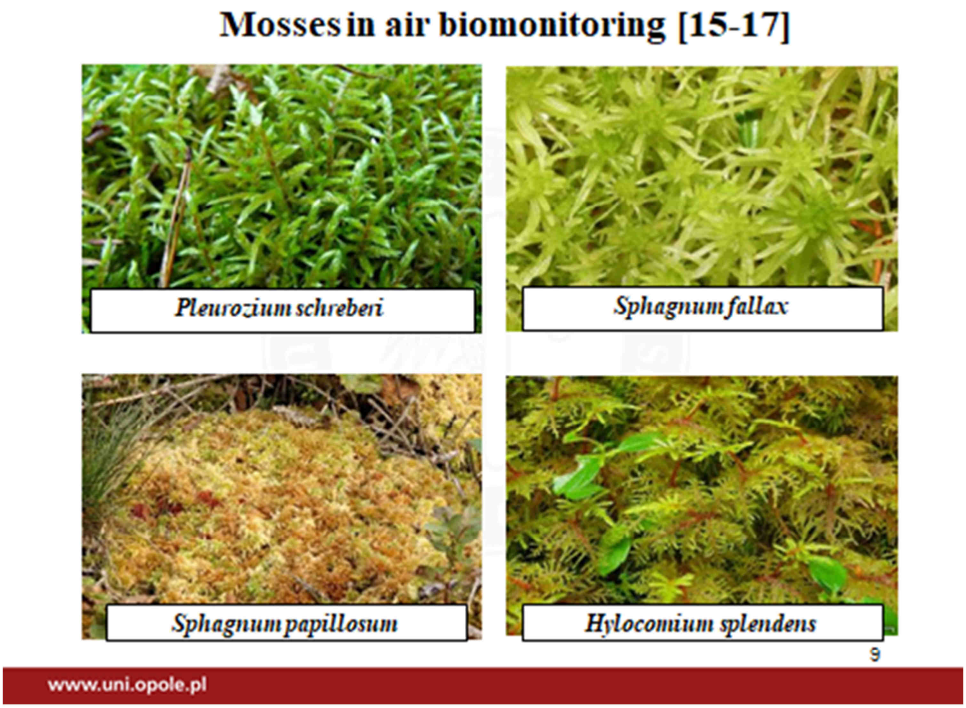
Mosses in air biomonitoring [15-17]
Pleurozium schreberi
Sphagnum fallax
Sphagnum papillosum
Hylocomium splendens
9
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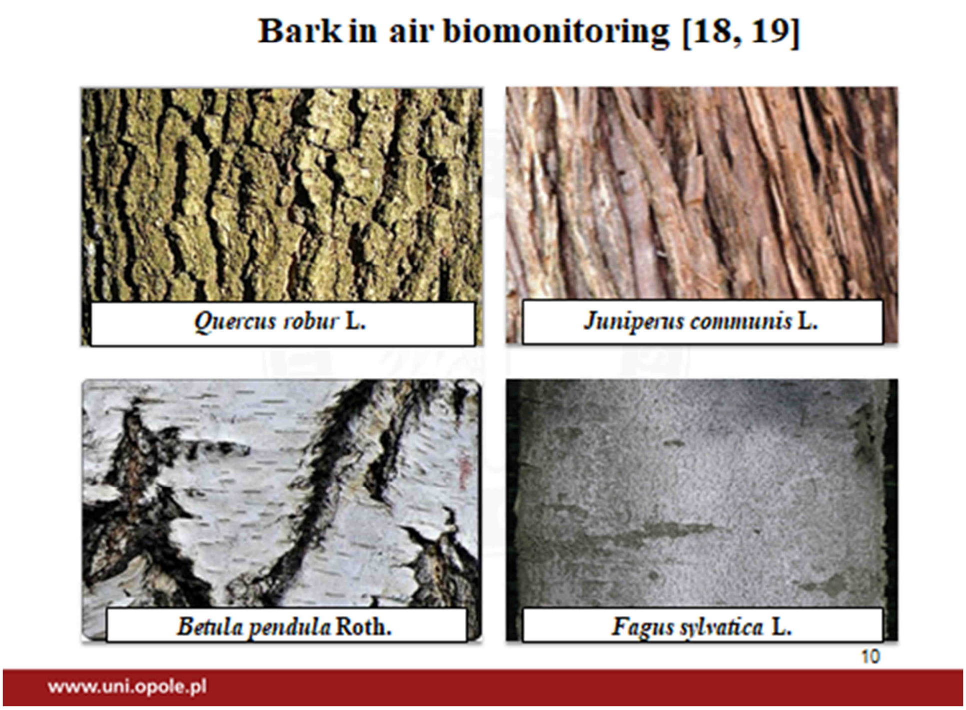
Bark in air biomonitoring [18, 19]
Quercus robur L.
Juniperus communis L.
Betula pendula Roth.
Fagus sylvatica L.
10
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Assessment of pollution of studied areas


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PASSIVE AND ACTIVE BIOMONITORING OF ATMOSPHERIC AEROSOL WITH THE USE OF MOSSES

Introduction

Biomonitoring research in Poland
Analysed, among others accumulated trace elements in mosses [20].

11

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Origin of impurities


atmosphere

Air Quality during New Year's Eve: A Biomonitoring Study with Moss

Active biomonitoring with the use of *Pleurozium schreberi* mosses was used to assess air pollution during the combustion of fireworks [21-24].

12

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For years we are performing the long term research. The aim of it is to assess the impact of car traffic on the deposition of pollutants near traffic routes.

Hypogymnia physodes

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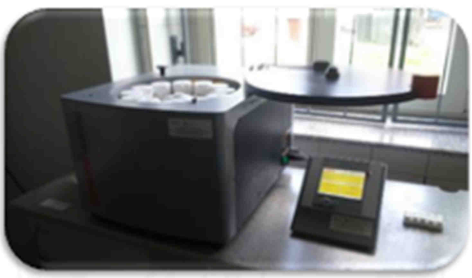
In all lichens samples the heavy metals (Mn, Fe, Ni, Cu, Zn, Cd and Pb) concentrations were determined using *FAAS*



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Measurement of heavy metals concentration by the AAS method

Metal	BCR-482 *lichen*		AAS		*Dev.* *
	Concentration	±*SD*	Concentration	±*SD*	
	[mg/kg d.m.]				[%]
Mn	33.0	0.5	31.2	0.8	-5.5
Fe	804	160	n.d.	n.d.	n.d.
Ni	2.47	0.07	2.16	0.32	-13
Cu	7.03	0.19	6.54	0.18	-7.0
Zn	100.0	2.2	93.9	2.5	-6.7
Cd	0.56	0.02	0.52	0.04	-7.1
Pb	40.9	1.4	38.2	1.0	-6.6

* - relative difference between the measured and certified concentration $100\% \cdot (c_x - c_c)/c_x$

The certified reference materials are BCR-482 *lichen* *and* BCR-414 *plankton*

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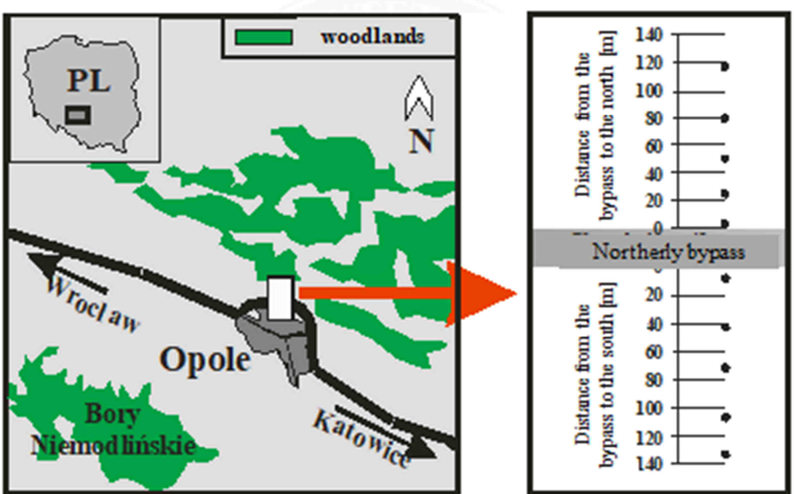
Impact of car traffic on deposit pollution near traffic routes [25]



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Impact of car traffic on deposit pollution near traffic routes

The results were interpreted by determining the *RAF* (*Relative Accumulation Factors*) [26]:

$$RAF = (c_{x,1} - c_{x,0}) / c_{x,0}$$

where:

$c_{x,0}$ - analyte concentration before the exposure period

$c_{x,1}$ - analyte concentration after the exposure period

17

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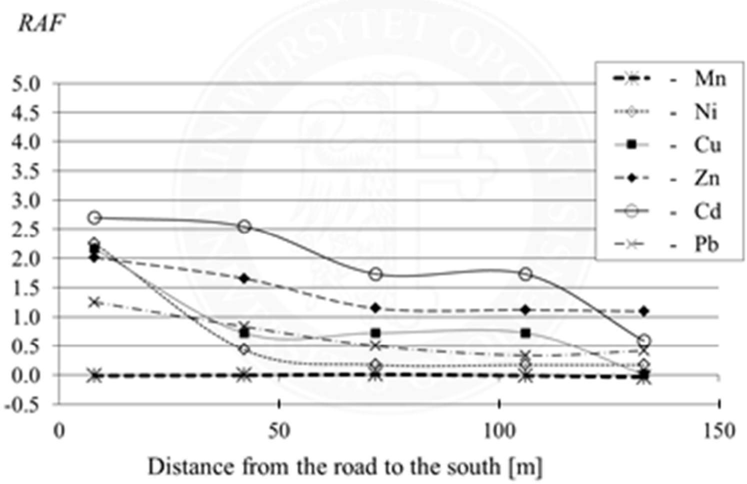
Impact of car traffic on deposit pollution near traffic routes



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For the best heavy metal bioaccumulators **moss and lichen** are recognised in the atmospheric aerosol.

Mosses, due to their anatomical structure and specific diet, absorb substances contained in the air very well [27].

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Tobacco smoke consists of **almost 4,000 chemical compounds, of which over 40 are carcinogenic substances.** Their activity is not limited only to smokers, but also applies to all those who stay in rooms where there is tobacco smoke (so-called passive smoking) [28, 29].

20

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The effect of smoking on the human body

The average smoker smokes about 15 cigarettes a day. By smoking 45 years, a smoker is able to smoke 246,375 cigarettes during his lifetime.

The main groups of nicotine-related disorders are: cancer (lung cancer, esophageal and larynx cancer, kidney cancer, oral cancer and pancreatic cancer) and pulmonary insufficiency, coronary heart disease and digestive system diseases.

After 20 years of smoking, we spend 21 000 € …

21

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The use of mosses as a biosensor for air pollution, in living quarters, with analytes derived from tobacco smoke [30].

Pleurozium schreberi

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Research methodology

Heavy metal concentration measurement using the AAS method

Mn, Fe, Ni, Cu, Zn, Cd and Pb

ICE 3500 device from Thermo Electron Corporation, USA

Hg

AMA mercury analyser

23

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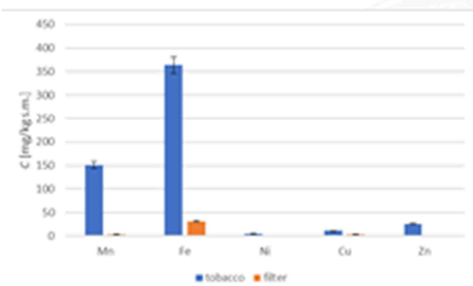
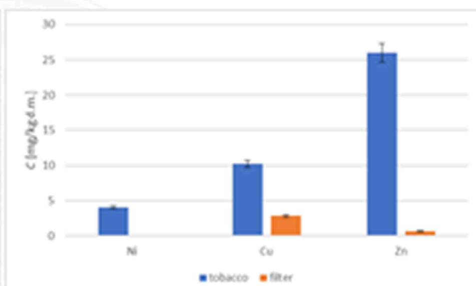
Heavy metal content in popular cigarettes





c_{Cd} < 0.81 mg/kg d.m.

c_{Pb} < 4.38 mg/kg d.m.

In tobacco marked c_{Hg} = **0.0031** mg/kg d.m.

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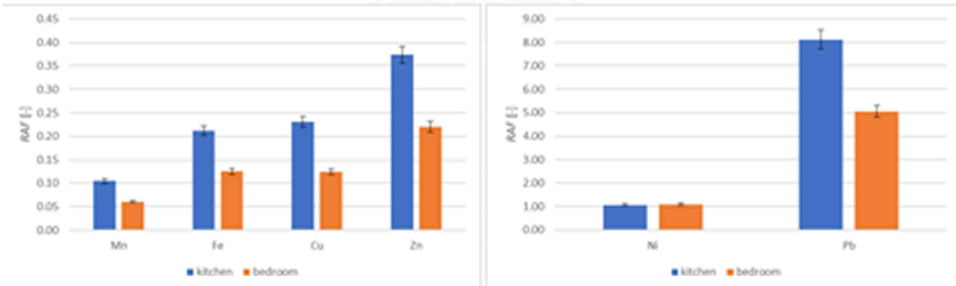
Heavy metal content in mosses after the exposure period



$$RAF_{Hg} = 0.021 \text{ mg/kg d.m.}$$

The aim of the presented study was to compare the contamination of forests in southern and north-eastern Poland with the heavy metals: Mn, Fe, Ni, Cu, Zn, Cd and Pb – including in terms of seasonal changes – and to identify the potential sources of these metals [31].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THE USE OF BARK IN BIOMONITORING HEAVY METAL POLLUTION OF FOREST AREAS ON THE EXAMPLE OF SELECTED AREAS IN POLAND

Introduction

Betula pendula **Roth.**

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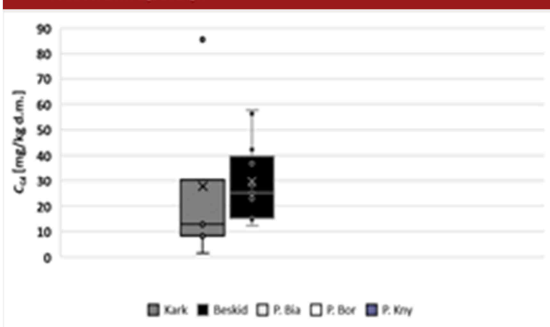
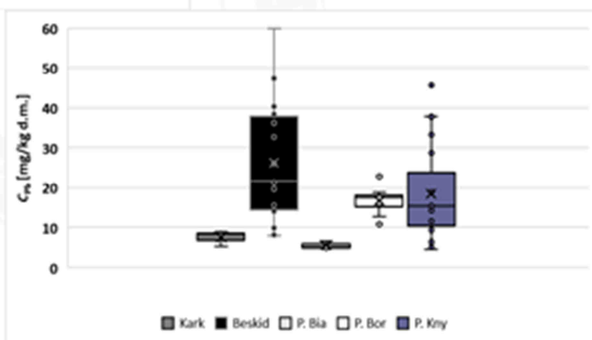


In terms of Mn, Ni, Cu, Cd and Pb pollution, the studied areas can be ranked in the following order: southern areas of the country > north-eastern Poland.



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Main research topics implemented in water biomonitoring [32-37]:

- assessment of contamination of the tested reservoirs aquatic (saltwater and freshwater)
- identification of pollution sources
- long-term monitoring and designation
- trends in changes in the composition of pollutants
- comparative study

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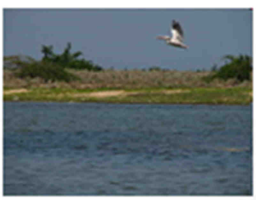
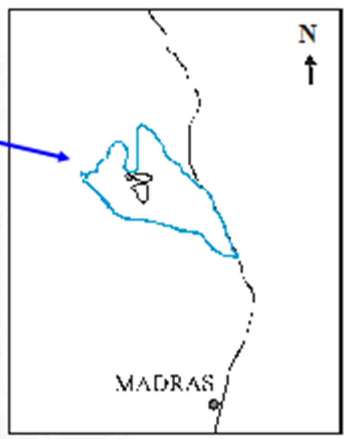
Pollution assessment of tested water reservoirs



Pulicat Lake



Biomonitoring research on Pulicat Lake (south-east India). Heavy metals: Cd, Cr and Pb were determined in *Ulva lactuca* algae [38].

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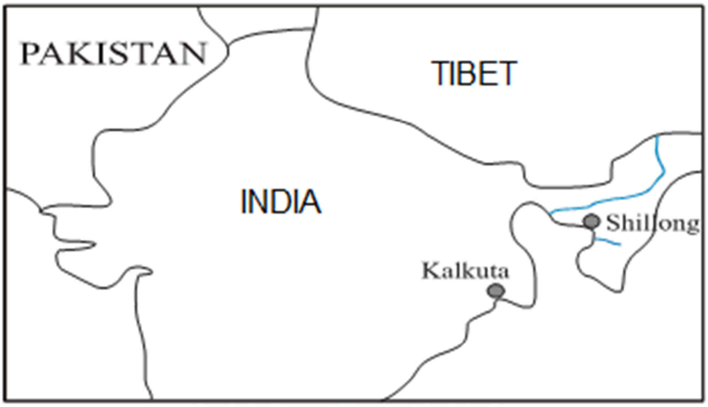
Comparative study



Heavy metal contamination of two watercourses near the city of Shillong was investigated [39]

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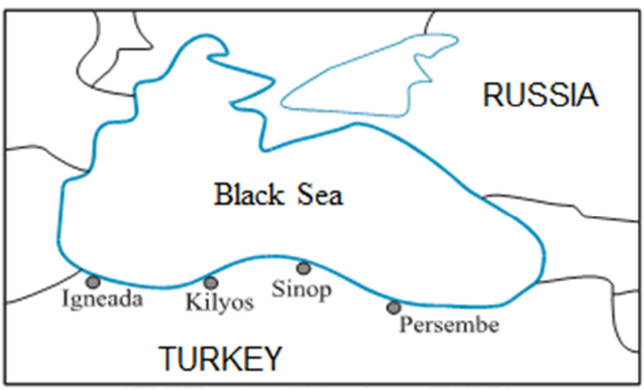
Long-term monitoring of water reservoirs



In the years 1997–1998 biomonitoring studies of the Black Sea were conducted. Heavy metals were determined in algae: Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn. In 1998 the concentration of Co, Mn, Ni and Zn increased as compared to 1997 [40]

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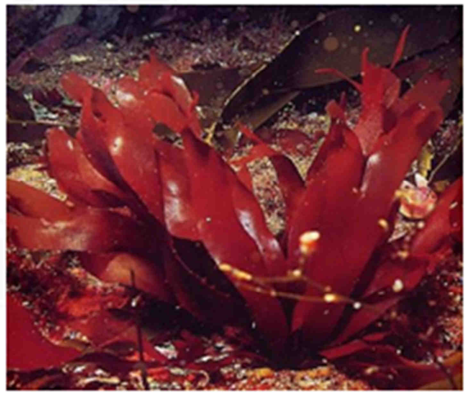
Active biomonitoring of the Jastrzebianka river [41]



Palmaria palmata

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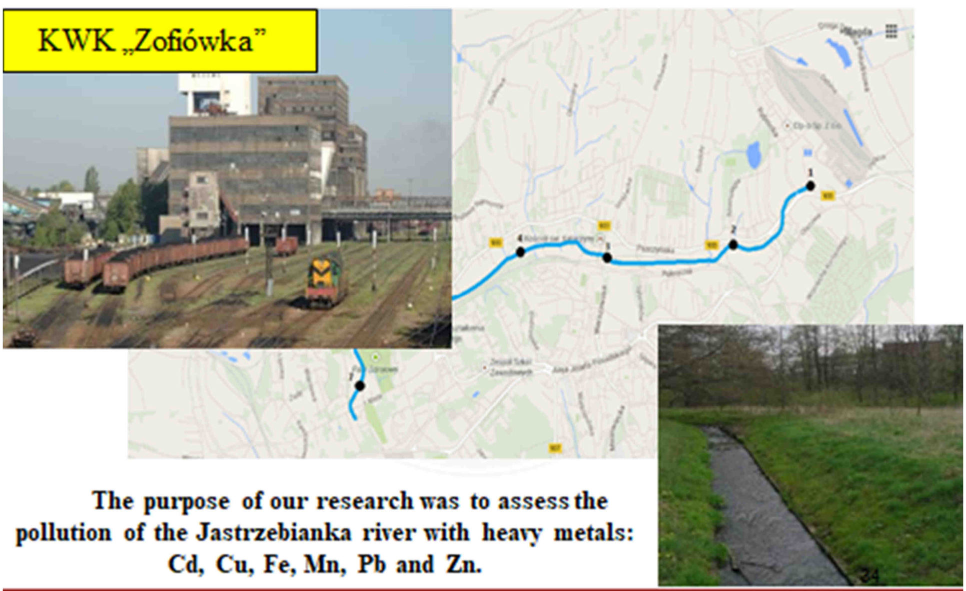
Places displaying algae samples of *Palmaria palmata*



The purpose of our research was to assess the pollution of the Jastrzebianka river with heavy metals: Cd, Cu, Fe, Mn, Pb and Zn.

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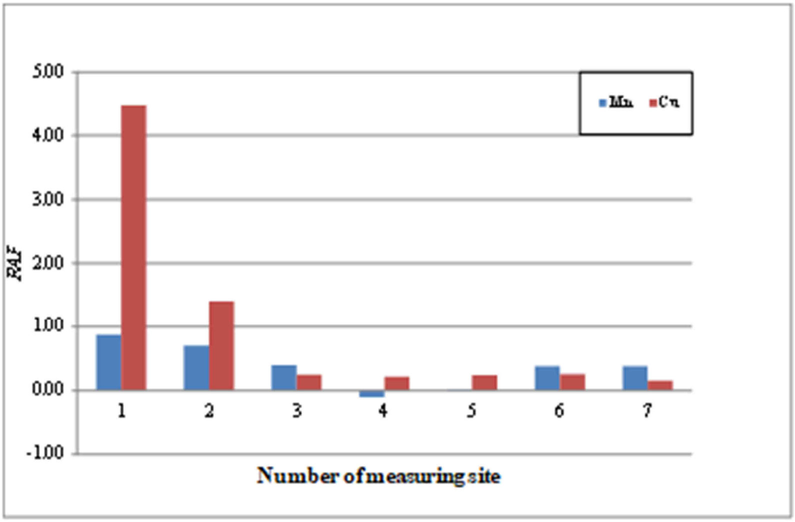
Active biomonitoring of the Jastrzebianka river



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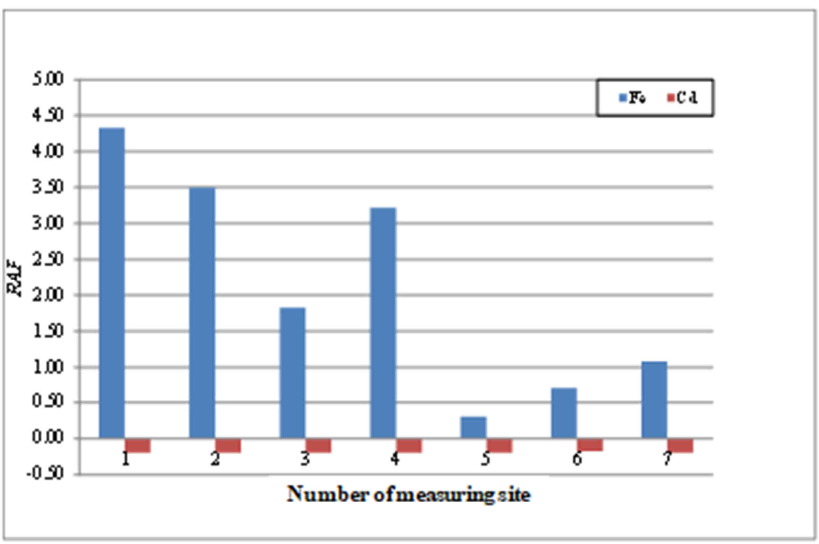
Active biomonitoring of the Jastrzebianka river



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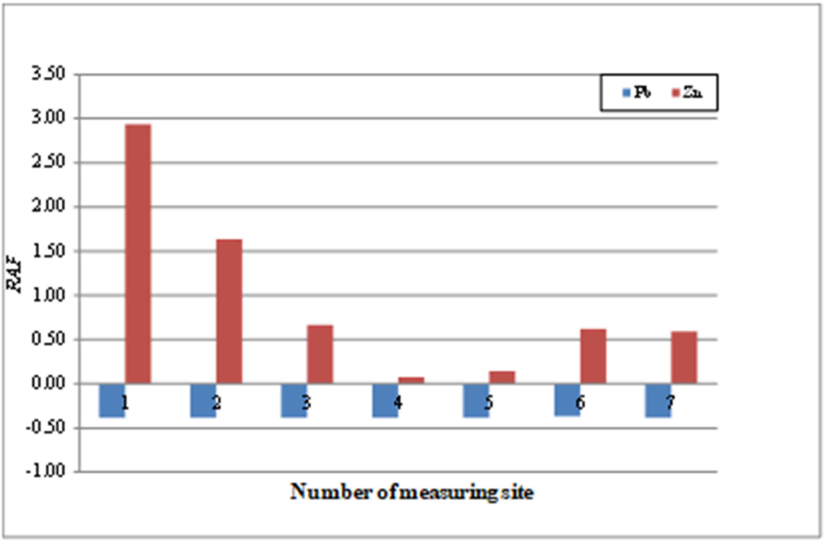
Active biomonitoring of the Jastrzebianka river



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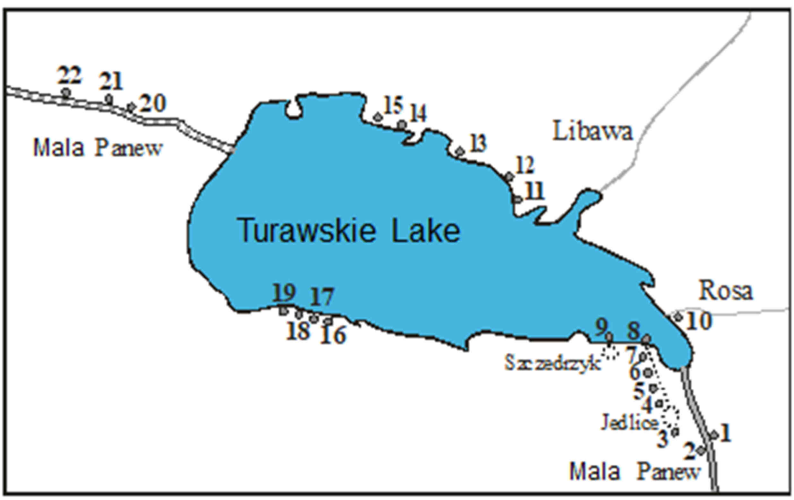
Passive biomonitoring of the Turawskie Lake [42]



Research area with marked places sampling

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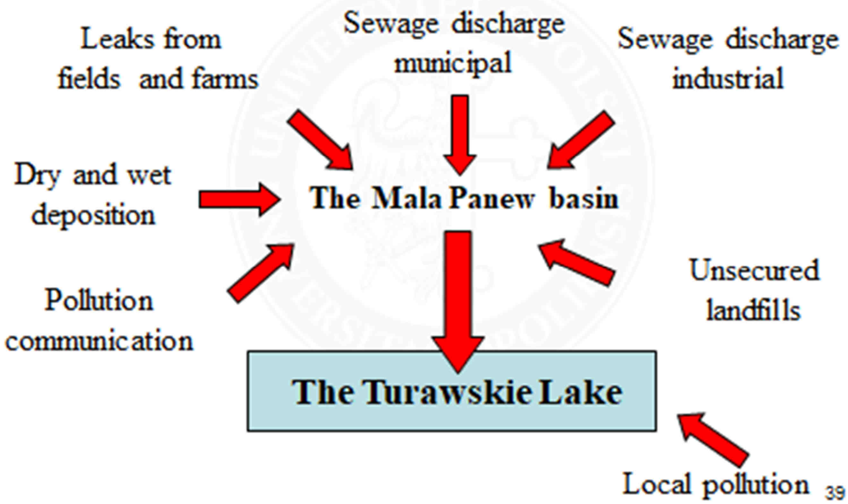
Pollution sources of the Mala Panew basin and the Turawskie Lake [43]



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The purpose of our research was to assess the pollution of the Turawskie Lake with heavy metals: Cd, Cu, Fe, Mn, Pb and Zn.

Spirogyra sp.

40

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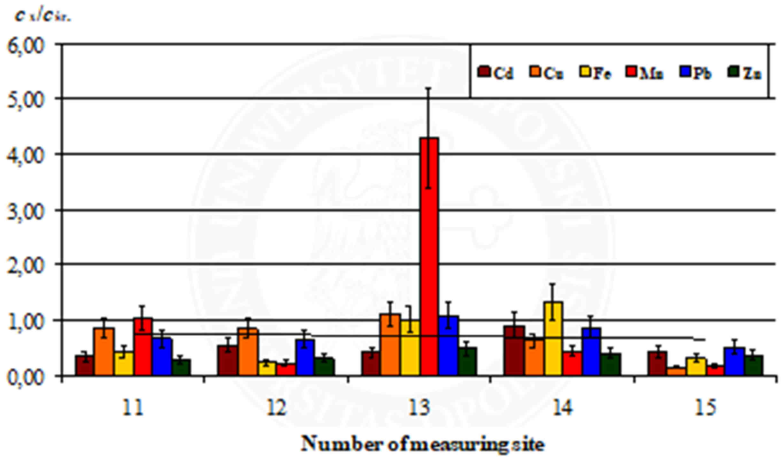
Results of biomonitoring research



The content of heavy metals in algae samples taken from measuring sites located along the northern shore of the Turawskie Lake

41

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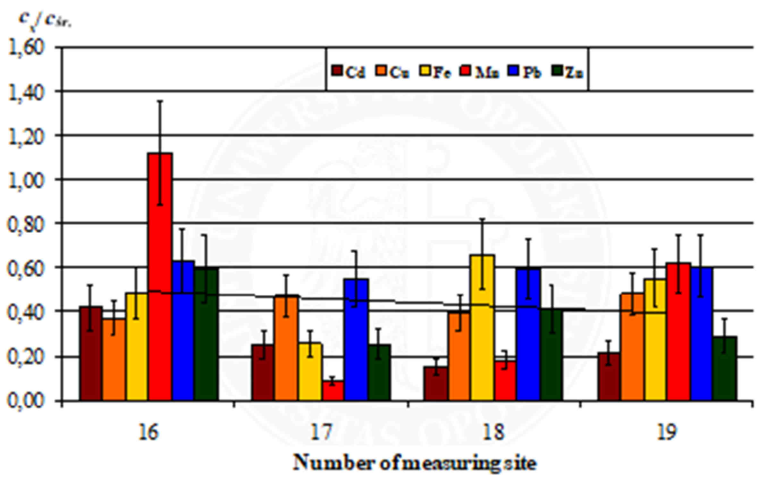
Results of biomonitoring research



The content of heavy metals in algae samples taken from measurement sites located along the southern shore of the Turawskie Lake

42

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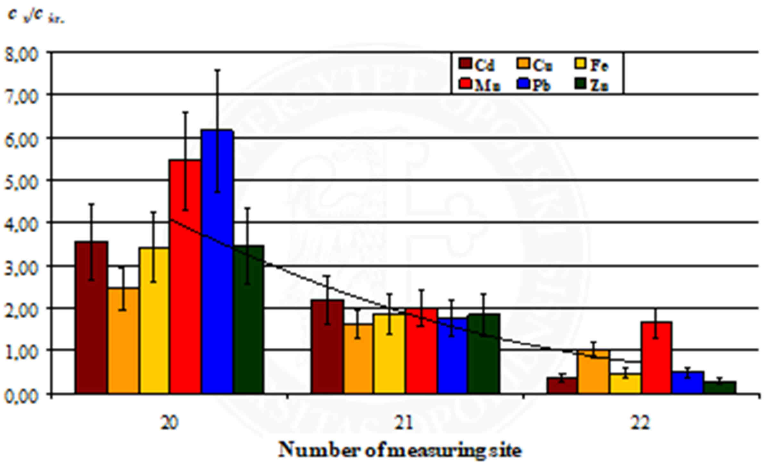
Results of biomonitoring research



The content of heavy metals in algae samples taken from measuring sites located along the Mala Panew river

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Summary and conclusion

The great interest of research centers in bioindicators of environmental pollution results from the simplicity and low costs of obtaining research material [44].

Analysis of the concentration of trace elements associated in lichens, mosses and algae it provides a lot of information about pollutants introduced into the environment, allows assessment of environmental quality changes and allows to determine the sources of these pollutants [45].

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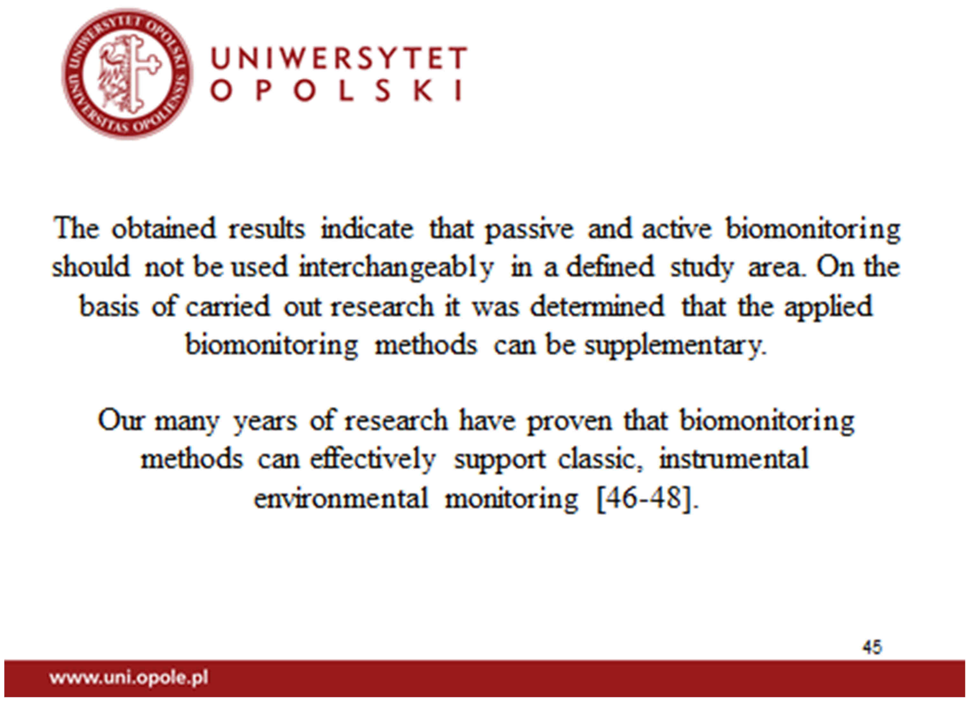

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