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BIOINDICATORS, A KEY TOOL IN ASSESSING TOXIC EXPOSURE

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Abstract

Biomonitoring uses living organisms - bioindicators - to assess environmental health, while biomonitors specifically provide quantitative data on pollution levels, such as accumulation rates. Bioindicators - plants and animals - can provide valuable information about ecosystem exposure to a wide range of pollutants, as they are able to absorb and accumulate specific toxins from soil, water and atmosphere. This paper provides an overview of the main aspects of the potential of biomonitoring as an effective tool for assessing exposure to toxic substances and for identifying interventions needed to mitigate it.

Key words*: bioindicators, biomonitoring, ecosystem damage, environmental contaminants, environmental pollution.*

INTRODUCTION

Biomonitoring is a key tool when it is necessary to identify the presence of pollutants in biological substrates, to quantitatively and qualitatively assess exposure, as well as to estimate the level of exposure (Tadic, 2025).

The concept of monitoring derives from the verb "to monitor" which originates from the Latin verb "moneo", which means to warn, remind or recommend (Stoddard et al., 2006).

Industrial and domestic human activities have led to environmental pollution, and industrial growth and the gradual transition to urbanization are the main causes of the increase in various types of environmental pollutants (Cozea & Tanase, 2022).

In Romanian, the term "monitoring" is used relatively recently, and, in a broader sense, represents the supervision of the evolution in time of a natural or artificial system, by determining, evaluating or warning about the exceeding of limit values of important indicators or parameters of the system (Maciuca, 2004).

The fundamental reasons for using bioindicators are based on demonstrating how the biological effect of pollutants is integrated with the sensitivity of biological sensors and environmental climatic factors (Macoveanu, 2006).

By extrapolating the toxic risk from plants to humans, the toxic potential on humans is demonstrated and, implicitly, the possibility of standardizing working methods (Krishnaveni, 2013). The importance of biomonitors (Figure 1) is reflected in parameters related to human health, environmental quality, biodiversity and ecological significance.

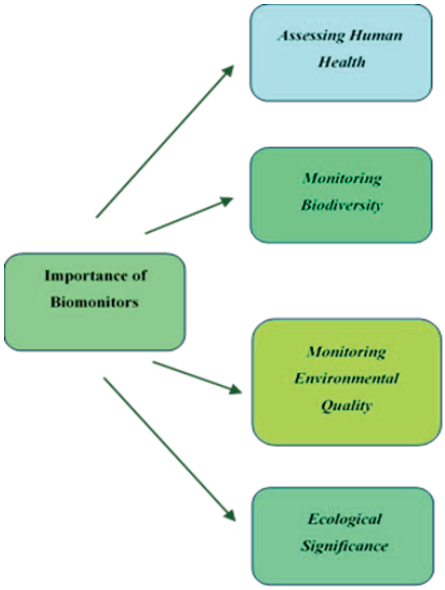

Figure 1. The importance of biomonitors (Holt & Miller, 2010)

This process can sometimes lead to a diagnosis of the current state and possibly the development of forecasts (Environmental Protection Agency, 2025).
This review provides a synthesis of the main aspects related to bioindicators as effective tools for assessing exposure to toxic substances and for identifying actions required to mitigate this exposure.

BASIC ACTIVITIES IN BIOMONITORING

Environmental monitoring is the systematic and continuous process of collecting and analysing data on natural resources - such as air, water, soil, and biodiversity - to assess environmental conditions, impacts, and ensure compliance with environmental standards (Holt & Miller, 2010).
Environmental monitoring consists of three basic types of activities:

- the first activity involves measurements and observations aimed at ensuring a correct description of the environment and the changes to which it may be subject;
- the second activity is represented by the evaluation of environmental data to determine possible directions of evolution and the development of an early warning system based on pre-established criteria, but which are in continuous evolution with the development of scientific knowledge;
- the third activity within of the system is to plan actions that prevent environmental deterioration and ensure optimal environmental management.

Significantly, monitoring provides not only the basis for the formulation of environmental policies, but also allows for the evaluation of the effectiveness of these policies. Data relating to the quality of environmental factors, processed through a cycle involving multiple vertical and horizontal levels, become information on environmental quality (Ahluwalia, 2025).
The vertical levels include the activities and operations that take place from the level of measuring/sampling stations to the users of information on the quality of environmental factors (Scheepers, 2025)
The horizontal data loop in biomonitoring based on bioindicators focuses on the spatial distribution of sampling and their analysis in direct relation to a pollution source or a given geographical area, ensuring horizontal coverage (mapping) of environmental quality (Aslam et al., 2012).
Environmental teams within environmental organizations involved in biomonitoring must collect, interpret, evaluate and report on deviations, the amount of data involved is often large. This makes the task time-consuming, especially when it is hampered by unsuitable tools for the task, such as spreadsheets, which can be time-consuming, error-prone, unreliable and lack data traceability (Kettrup, 2003).

PRIORITY OBJECTIVES OF BIOMONITORING

The national environmental quality monitoring system was established in the 1960s, but systematic observations began to be carried out in the 1980s, currently having as priority objectives:

- monitoring of environmental quality and determining the level of pollution;
- detecting cases of exceptional pollution of surface water, air and soil;
- preventing and reducing negative effects on the environment and the population;
- emergency notification of decision-making bodies regarding the exceptional degree of environmental pollution;
- systematic familiarization of the public with environmental quality (Environmental Protection Agency, 2025).

Thus, the marked persistence of pollutants in environmental media and its pronounced toxicity determine the increased danger of these pollutants for humans and wildlife. All these characteristics impose the need to implement measures to monitor pollutant levels in the environment and the impact on human health, especially young children (Barmashova & Lazutkina, 2019).
Human activity is a component of natural ecosystems and, over time, its influence on these ecosystems has undergone fundamental transformations. If initially the anthropogenic changes in ecosystems were imperceptible, with the advancement of human society, the effects have become increasingly visible. The degree of human interference in ecosystem functioning has progressively intensified, ultimately reaching the point of affecting the ecosphere (Kettrup, 2003).

The evidence of the negative effects of massive human intervention on ecosystems, which affected the very complex but also very sensitive balance of the biosphere, alarmed people, perhaps too late. As a result of anthropogenic activity, global climate changes have already occurred, as well as global biogeochemical cycles, with repercussions on all terrestrial ecosystems (Contrea & Contrea, 2000).
The implications of this state of affairs can become very serious, as human survival and continued development depend on the proper functioning of these ecosystems. With growing awareness of the risks posed by the ecosystem imbalances, efforts have been undertaken to develop systems for their monitoring (Abbott & Le Maitre, 2009).

BIOMONITORING SURVEILLANCE

Biomonitoring surveillance is essential for assessing human exposure to environmental and occupational hazards and evaluating associated public health risks. The surveillance implies two directions:

- the early detection of possible changes in the functioning and composition of biological systems, which could ultimately lead them to disorganization, collapse, or could commit them to an unfavourable direction of evolution. Early alerting of specialists enables decision-makers to take measures to remedy the situation, before irreversible negative effects occur;
- study the reaction and response of biosystems to global environmental change.

The information obtained from the surveillance systems is stored in databases, to allow comparisons over time (Weinhold, 2010).
Globally, there are several networks for monitoring ecosystems or only certain abiotic parameters. These networks have a varying density and extent and are equipped with more or less sophisticated equipment (Bellinger & Needleman, 2003).

INSTRUMENTAL OR BIOLOGICAL MONITORING

Biological monitoring or biomonitoring may complement and, in some cases, replace instrumental monitoring. Biomonitoring is preferable to instrumental monitoring, if there are not sufficient financial resources for the installation and maintenance of sophisticated equipment (as is generally the case in developing or underdeveloped countries). Biomonitoring is very convenient for cases where the long-term monitoring of large areas is sought (Creager, 2018).
Instrumental monitoring is not defined by time resolution alone; it also includes continuous monitoring systems. Instrumental monitoring also includes biotic parameters (e.g., DNA-based sensors, biochemical assays). Many instrumental methods provide derived, qualitative or semi-quantitative interpretations after processing (Tranfo, 2020).
Bioindicators are species, populations, or communities of species that, due to their variability (biochemical, physiological, ethological or ecological), allow the characterization of the state of an ecosystem and highlight, as early as possible, its natural or anthropogenic changes (Holt & Miller, 2010).
The idea of a bioindicator species was introduced when the indicator capacity of lichens was observed regarding the composition, quality and humidity of the air. In the second half of the 20th century, research generally aimed at finding indicators and developing methods that would provide information related to air, soil and water pollutants (Birsan & Luca, 2010).
Subsequently, as concerns regarding ecosystem degradation expanded, efforts were made to identify bioindicators that would provide information on ecosystem stability, biodiversity maintenance, sustainable management of forest or agricultural ecosystems - the effect of certain management measures or techniques on these ecosystems, or information on the response of ecosystems to global climate change (Cozea & Tanase, 2019).

BIOINDICATORS OF POLLUTION - OVERVIEW

A biological monitor or biomonitor is an organism that provides indirect information on the quality of the environment around it. Pollution indicators are physical, chemical or biological variables, and they can help assess contamination levels of air, water or soil, reflecting environmental quality and health risks (Pauline et al., 2007).

Regarding pollution indicators, there are two types:

- specifically sensitive, which indicate the presence of a pollutant through the appearance of lesions or malformations;
- specifically accumulator, which concentrate the pollutant in their body, which proliferate and become abundant in polluted areas.

Pollution indicators can be animal or plant, the latter being more numerous (Gavrilescu & Pavel, 2008).

Bioindicators for pollution have the advantage, compared to instrumental monitoring, of being able to provide an answer to the combined effect of certain pollutants, unlike instruments that measure the amounts of each pollutant separately. Bioindicators can give indications, following tissue analysis, related to very small amounts of pollutants in the environment, as well as the evolution of the pollutant over time, over longer periods (Baconi & Bălălău, 2001).

As mentioned, the first and most widely used species as indicators of air quality were lichen species. Their value as bioindicators has been recognized since a 100 years ago, but concrete methods for monitoring air pollution with sulphur dioxide, through lichens, have been developed and improved in the last 30 years (Barr, 2008).

BIOINDICATORS OF POLLUTION – PLANT

Plant species that have been used as bioindicators of ozone pollution, along with other indicators of air pollution, can be classified into two categories:

- introduced species, generally herbaceous, fast-growing, genetically uniform plants, generically called "sentinel species", used in active biomonitoring;
- species that grow naturally in a given area, are perennial plants, shrubs or trees, slow-growing and have a slow reaction to increasing pollutant concentrations, the effects appearing later, during the growth period; these species are generically called "detector species" or biomonitors, used in passive monitoring.

Examples of species in the first category are tobacco (*Nicotiana tabacum* L.) and stinging nettle (*Urtica urens* L.), and for species in the second category, it could be mentioned: American black cherry (*Prunus serotina* Ehrh.), yellow pine (*Pinus ponderosa* Laws.), American ash (*Fraxinus americana* L.), Pennsylvania ash (*Fraxinus pennsylvanica* Marsh.), quaking aspen (*Populus tremuloides* L.), tulip tree (*Liriodendron tulipifera* L.) (Dobrota, 2010).

By monitoring these sentinel plants - often planted in strategic locations like botanical gardens, nurseries, or near ports - researchers can identify early warning signs of threats that are otherwise difficult to spot. Sentinel species usually react quickly to increased ozone concentrations in the air, being used to signal its presence early. However, responses may be more pronounced in young plants and therefore plants should be reintroduced periodically. (Mansfield et al., 2019)

They are previously cultivated in clean air, free of pollutants and subsequently transplanted to monitoring sites; being genetically uniform, their reaction to the pollutant is relatively uniform (Grandjean & Landrigan, 2014).

Detector species are not subject to special care measures in the natural environment in which they grow. It should be noted that only some individuals in a population, namely the sensitive ones, react to elevated ozone levels. The reaction of individuals is also conditioned by other seasonal conditions (Krishnaveni & Magesh, 2014).

As some examples, these plant species are used as bioindicators for various pollutants: St. John's wort (*Hypericum perforatum*) for hydrofluoric acid, stinging nettle (*Urtica doica* L.) for ozone and peroxyacetyl nitrates, ryegrass (*Lolium* spp.) for hydrofluoric acid and heavy metals, valerian (*Valeriana officinalis*) for heavy metals, alfalfa (*Medicago sativa* L.) for sulfur dioxide, barley (*Hordeum vulgare* L.) for heavy metals and fluorinated compounds, corn (*Zea mays* L.) for hydrofluoric acid, sulfur dioxide, heavy metals. (Caliman et al., 2011).

BIOINDICATORS OF POLLUTION – INSECTS

Along with plants, insects are used as bioindicators of pollution, such as the elder aphid (*Aphis sambucci* L.) for sulfur dioxide, and among mammals, the rat (*Rattus rattus* L.) for nitrogen dioxide. As mentioned, biological

indicators are not only used in the case of pollution, but also for other purposes (Rosianu et al., 2022).

Thus, ants (fam. *Formicidae*, ord. *Hymenoptera*) are used as bioindicators in the conditions of ecological recovery in certain areas (areas degraded by mining activities, areas destroyed by fires) or as bioindicators of diversity. In general, the ant communities in the respective areas and their relationships with prey or predators are studied (Lutinski, 2024).

Other insect species, namely ground beetles (fam. *Carabidae*, ord. *Coleoptera*), are a reliable indicator of the distribution of vegetation: there are species characteristic of the alpine, subalpine or forest environment. These species have, in relation to abiotic (and implicitly biotic) conditions, very strict requirements (in fact, a condition for choosing bioindicator species is that they are stenotopic species); in addition, ground beetles are characterized by great mobility, so that any disturbance of their specific microclimate determines a rapid reaction and the movement of individuals to another, more convenient habitat (Dickie & Tucker, 2010).

The response of insects to environmental changes is faster than that of vegetation, for example. Inventorying, at regular time intervals, the communities of ground beetle species and storing this information in databases can provide, by comparison, information regarding the dynamics of ecosystems (Pont et al., 2006).

Other insects, such as dragonflies (ord. *Odonata*), can provide, by studying the evolution of their spatial distribution, indications about the occurrence of a disturbance in the functioning of the ecosystem of which they are part. Butterflies (ord. *Lepidoptera*) can provide information about the reappearance and succession of plant species on denuded land. Spiders (ord. *Araneae*) can also be used as bioindicators of ecosystem balance (Dickie & Tucker, 2010).

BIOINDICATORS OF POLLUTION – BIRDS

Birds play an important role as bioindicators: birds are conspicuous, relatively easy to observe, one of the best studied groups of organisms, and in the focus of public interest and care (Becker, 2003).

Birds are very good bioindicators (and in some cases, the only ones) of environmental changes, to which they react by modifying the composition of species within a biocenosis, by modifying their behaviour or appearance and reproductive capacity (Cotin, 2012).

Birds can be used to examine the long-term effects of their habitat fragmentation, the effect of introducing new species into the ecosystem, to monitor water quality, to obtain information on the health of fish populations, to identify pollutants such as organochlorine pesticides, heavy metals or radioactive substances (Aktar et al., 2009).

An advantage of using birds as bioindicators is that they have been studied in detail in the past and, as a result, there is already a lot of data available regarding their natural distribution, ecology and ethology, which can be compared with new data obtained from ecosystems possibly affected by degradation or various disturbances (Becker, 2003).

Thus, for the monitoring of water quality in mountain springs in forest ecosystems, the wagtail (*Motacilla alba*) is used as a bioindicator in the United States. It was chosen as a bioindicator for the stability of forest ecosystems that host springs, for establishing priority measures for the conservation of these ecosystems and for establishing objectives for ecological reconstruction, where appropriate (these ecosystems being affected by the fragmentation of forest areas and the acidification of waters due to mining drainage techniques). The wagtail was selected as a bioindicator because it is linked to both mountain water quality and large areas of mature forest (Brooks, 2000).

Various species of owls have also been used as sentinel species for early warning of ecosystem degradation. These species, like other predator species, have been used as biomonitors because they are widely distributed, have territorial behaviour, are not migratory, and a fast metabolism (Wendaisaul, 2015).

Owls, considered bioindicators of environmental health, excel due to their position as higher-order consumers - top predators - in the food chain. Due to this fact, they accumulate and concentrate large amounts

of pollutants ingested by prey - rodents, insects - a process known as bioaccumulation (Popescu, 2010).

Species used as indicators in various parts of the world, especially in North America (Canada and the USA), Europe (Norway, the Netherlands, Spain, Great Britain) and Africa (South Africa) are represented by several owl species (*Asio otus* L., *Tyto alba* L., *Bubo bubo* L., *Bubo virginianus* L., *Asio flammeus* L., *Glaucidium perlatum* L.) (Wendaisaul, 2015).

The use of species (such as raptors, peregrine falcons or various passerine species) as bioindicators for monitoring ecosystem health and pollution involves a multidisciplinary approach. These studies focus on the effects of contaminants on animal physiology and behaviour:

- reproductive behaviour changes – monitoring nesting success, chick feeding frequency and courtship behaviour, which can be affected by exposure to pesticides (e.g. organochlorines);
- study of eggshell thickness - a classic indicator of pollution, especially in the case of pesticides such as DDT, which cause the shell to thin, leading to the cracking of eggs during hatching;
- analysis of the activity level of liver enzymes (e.g. cytochrome P450) to assess exposure to xenobiotics and the body's ability to metabolize toxins;
- the use of non-killing samples, essential for the study of endangered species (Mitrofan et al., 2022).

Another bioindicator that has been frequently used and well studied is the peregrine falcon (*Falco peregrinus* L.), whose populations have experienced a drastic decline in the past due to exposure to dichlorodiphenyltrichloroethane (DDT) and other organochlorine insecticides. After the banning of these insecticides, populations of the species recovered in many countries and interest in this species as a bioindicator decreased, its place being taken by the various owl species mentioned above (Askeyev et al., 2019).

CONCLUSIONS

Bioindicators open up a wide field of research; numerous research projects are currently underway and being finalized, as there are still many aspects to be clarified and it is necessary to develop coherent methods for environmental monitoring using bioindicators.

Biological monitoring and biological effects monitoring can play a role in exposure assessment and health surveillance, helping to evaluate control measures and manage risks to human health and the environment in which they live.

For practical application, species must be carefully selected based on their ability to provide relevant information for specific monitoring objectives, as well as on well-documented relationships with environmental factors and other components of the biocenosis.

When developing specific monitoring methods, the scale at which the determinations are made and the exact data that are collected must be taken into account, as well as the way in which these data are processed and stored, so that they are relevant and the interpretations made on their basis are as close to reality as possible.

Taking into account the financial difficulties existing in our country and other objective reasons, which make the instrumental surveillance of forest ecosystems difficult, biomonitoring represents a particularly interesting alternative (or a possible complement).

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REFERENCES

Abbott, I. A. N. & Le Maitre, D. (2009). Monitoring the impact of climate change on biodiversity: the challenge of megadiverse Mediterranean climate ecosystems. *Austral Ecology*, 35(4), 406–422.

Ahluwalia, P., S. (2025). Environmental Valuation and Natural Resource Pricing: Tools for Policy and Planning. *Interdisciplinary Journal of the African Alliance for Research, Advocacy and Innovation*, 1(1), 171–91.

Aktar, M. W., Sengupta, D., & Chowdhury, A. (2009). Impact of pesticides use in agriculture: their benefits and hazards. *Interdisciplinary Toxicology,* 2(1): 1–12.

Askeyev, A., Askeyev, O. & Askeyev, I. (2019). Owls as bioindicators: their spatal and temporal aspects in Eastern Europe. *European Journal of Ecology*, 5(2), 8-15.

Aslam, M., Verma, D. K., Dhakerya R., Rais, S., Alam, M. & Ansari, F. A. (2012). Bioindicator: a comparative study on uptake and accumulation of heavy metals in some plant′s leaves of M.G. Road, Agra City, India. *Research Journal of Environmental Earth Sci*ences 4(12), 1060–1070.

Baconi, D. & Bălălău, D. (2001). Toxicologia substanțelor naturale și inrudite. București, *Editura Technoplast*.

Barmashova, T. I. & E. V. Lazutkina, E. V. (2019) Environmental management factors. IOP Conference Series: *Earth and Environmental Science* 315, 072023.

Barr, D. (2008). Biological Monitoring: Theory and Applications - Bioindicators and Biomarkers for Environmental Quality and Human Exposure Assessment. *Environmental Health Perspectives*, 116(7): A312.

Becker, P.H. (2003). Biomonitoring with Birds. Trace Metals and Other Contaminants in the Environment. *Scientific Research*, 6, 677–736.

Bellinger, D. C. & Needleman, H. L. (2003). Intellectual impairment and blood lead levels. *The New-England Medical review and Journal,* 349(5), 500–502.

Birsan, E. & Luca, C. (2010). Speciation of heavy metals in surface waters polluted by anthropogenic activities. *Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry,* 11(4), 3279.

Caliman, F. A., Gavrilescu, M., Hlihor, R. M. & Pavel, V. L. (2011). Biophysico-chemical processes of hevy metals in soil environments, *Buletinul Institutului Politehnic*, Iasi.

Contrea, A. & Contrea, M. (2000). *Biochimia mediului înconjurător, bioconstituenții organismelor vii*. Timișoara, Presa Universitară Romana.

Cotín, M., J. (2012). Birds as Bioindicators of Pollution in Aquatic and Terrestrial Environments. [Available at: https://hdl.handle.net/2445/35946]

Cozea, A. & Tanase. G. (2022). Green biomonitoring systems for air pollution. *Engineering Proceedings*, 19(1), 8.

Creager, A. N. (2018). Human bodies as chemical sensors: A history of biomonitoring for environmental health and regulation. *Studies in History and Philosophy of Science*, 70, 70–81.

Dickie, I. & Tucker, G. (2010). The use of market-based instruments for biodiversity protection – The case of habitat banking – Technical Report. In European Commission. *Environment*. [Available at: http://ec.europa.eu/environment/enveco/pdf/eftec_habitat technical report.pdf.]

Dobrota, C. (2010). Fiziologia plantelor. Cluj-Napoca, *Editura Risoprint*.

Environmental Protection Agency (EPA). (2025). Environmental Monitoring: Clean Air Status and Trends Network (CASTNET). *U.S. EPA*.

Gavrilescu, M. & Pavel, V. L. (2008). Overiew of ex situ decontamination techniques for soil cleanup. *Environmental Engineering and Management Journal*, 7, 815–834.

Grandjean, P. & Landrigan, P. (2014). Neurobehavioural Effects of Developmental Toxicity. *The Lancet Neurology*, 13(3), 330–338.

Holt, E., A. & Miller, S. W. (2010). Bioindicators: using organisms to measure environmental impacts. *Nature*, 3(10), 8–13.

Kettrup, A. A. F. (2003). Environmental monitoring, *Environmental Engineering and Management Journal*, 2(2), 119–30.

Krishnaveni, M. & Magesh, P. (2014). Air pollution tolerance index induced by biochemical components in plants. *International Journal of Pharmacy and Pharmaceutical Sciences*, 6(5), 362–364.

Krishnaveni, M. (2013). Biochemical changes in plants indicating air pollution. *International Journal of Pharmacy and Pharmaceutical Science*, 5, 585–586.

Lutinski, J. A., Lutinski, C. J., Serena, A. B., Busato, M. A., & Mello Garcia, F. R. (2024). Ants as Bioindicators of Habitat Conservation in a Conservation Area of the Atlantic Forest Biome. *Sociobiology*, 71(1), e9152.

Maciuca, A., (2004), Aspects of bioindicators use in ecosystems biomonitoring (in Romanian), *Bucovina Forest*, XI, 53.

Macoveanu, M., (2006). Methods and techniques of environmental ecological impact (in Romanian), *Ecozone Publishing House,* Iasi, 18

Mansfield, S., McNeill, M. R., Aalders, L. T., Nigel L. Bell, L. N., Kean, J. M., Barratt, B. I. P., Boyd-Wilson, K. & Teulon, D. A. J. (2019). The value of sentinel plants for risk assessment and surveillance to support biosecurity, *NeoBiota*, 48, 1–24.

Mitrofan, C. E., Cretu, A., Mitrofan, C., Bar, C. & Ghiciuc, C. M. (2022). Amiodarone induced lung disease. *Archive of Clinical Cases*, 9(3), 126–132.

Pont, D., Hugueny, B., Beier, U., Goffaux, D., Melcher, A., Noble, R., Rogers, C., Roset, N. & Schmutz, S. (2006). Assessing river biotic condition at a continental scale: a European approach using functional metrics and fish assemblages. *Journal of Applied Ecology*, 4, 70–80.

Popescu, C., (2010). Poluarea cu metale grele - factor major in deteriorarea ecosistemelor. *Revista de Ecologie, ECOS*, 22, 30–34.

Rosianu, A. M., Leru, P. M., Stefan, S., Iorga, G. & Marmureanu, L. (2022). Six-year monitoring of atmospheric pollen and major air pollutant concentrations in relation with meteorological factors in Bucharest, Romania. *Romanian Reports in Physics*, 74, 703.

Scheepers, P. T. J. (2025). Biomonitoring − more than analysis of biomarkers: advancing the use of biological guidance values, *Environment International*, 202, 109665.

Stoddard, J. L., Larsen, D. P., Hawkins, C. P., Johnson, R. K. & Norris, R. H. (2006). Setting expectations for the ecological conditions of streams: the concept of reference conditions. *Ecological Applications*, 16, 1267–1276.

Tadić, D., Pires de Lima, A. & Ricci, M. (2025). Quality assurance and quality control for human biomonitoring data - focus on matrix reference

materials. *Analytical and Bioanalytical Chemistry* 417: 3513–3528.

Tranfo, G. (2020). The growing importance of the human biomonitoring of exposure. *International Journal of Environmental Research and Public Health*, 17(11), 3934.

Weidensaul, S. (2015). Peterson Reference Guide to Owls of North America and the Caribbean. *Houghton Mifflin Harcourt.*

Weinhold, B. (2010). CDC releases updated biomonitoring report, *Environmental Health Perspectives*, 118(2), A66.