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Ambient air — Biomonitoring with mosses — Accumulation of atmospheric contaminants in mosses collected in situ: from the collection to the preparation of samples

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National foreword

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Außenluft - Biomonitoring mit Moosen - Akkumulation von Luftschadstoffen in Moosen (passives Monitoring): Probenahme und Probenaufbereitung

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Foreword

This document (EN 16414:2014) has been prepared by Technical Committee CEN/TC 264 “Air quality”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2014, and conflicting national standards shall be withdrawn at the latest by August 2014.

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0 Introduction

0.1 Biomonitoring and air quality

The impact of air pollution is of growing importance worldwide. Local and regional assessment is necessary as a first step to collect fundamental information, which can be used to avoid, prevent and minimize harmful effects on human health and the environment as a whole. Biomonitoring may serve as a tool for such a purpose. As the effects on indicator organisms are a time-integrated result of complex influences combining both air quality and local climatic conditions, this holistic biological approach is considered particularly close to human and environmental health end points and thus is relevant to air quality management.

It is important to emphasize that biomonitoring data are completely different from those obtained through physico-chemical measurements (ambient concentrations and deposition) and computer modelling (emissions data). Biomonitoring provides evidence of the effects that airborne pollutants have on organisms. As such it reveals biologically relevant, field-based, time- and space-integrated indications of environmental health as a whole. Legislation states that there should be no harmful environmental effects from air pollution. This requirement can only be met by investigating the effects at the biological level. The application of biomonitoring in air quality and environmental management requires rigorous standards and a recognized regime so that it can be evaluated in the same way as physico-chemical measurements and modelling in pollution management.

Biomonitoring is the traditional way through which environmental changes have been detected historically. Various standard works on biomonitoring provide an overview of the state of the science at the time, e.g. [1], [2], [3] The first investigations of passive biomonitoring are documented in the middle of the 19th century: by monitoring the development of epiphytic lichens it was discovered that the lichens were damaged during the polluted period in winter and recovered and showed strong growth in summer [4]. These observations identified lichens as important bioindicators. Later investigations also dealt with bioaccumulators. An active biomonitoring procedure with bush beans was first initiated in 1899 [5].

0.2 Biomonitoring and EU legislation

Biomonitoring methods in terrestrial environments respond to a variety of requirements and objectives of EU environmental policy primarily in the fields of air quality (Directive 2008/50/EC on ambient air, [6]), integrated pollution prevention and control (Directive 2008/1/EC, [7], and Directive 2010/75/EU, [8]) and conservation (Habitats Directive). The topics food chain ([9]) and animal feed ([10], [11], [12]) are alluded to as well.

For air quality in Europe, the legislator requires adequate monitoring of air quality, including pollution deposition as well as avoidance, prevention or reduction of harmful effects. Biomonitoring methods appertain to the scope of short and long-term air quality assessment.

Directive 2004/107/EC of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air ([13]) states that “the use of bio indicators may be considered where regional patterns of the impact on ecosystems are to be assessed”.

Concerning IPPC from industrial installations, the permit procedure includes two particular environmental conditions for setting adequate emission limit values. The asserted concepts of “effects” and “sensitivity of the local environment” open up a broad field for biomonitoring methods, in relation to the general impact on air quality and the deposition of operational-specific pollutants. The basic properties of biomonitoring methods can be used advantageously for various applications such as reference inventories prior to the start of a new installation, the mapping of the potential pollution reception areas and (long-term) monitoring of the impact caused by industrial activity. The environmental inspection of installations demands the examination of the full range of environmental effects. For the public authority, biomonitoring data contribute to the decision-making process, e.g. concerning the question of tolerance of impacts at the local scale.

The Habitats Directive (92/43/EEC on the conservation of natural habitats and of wild fauna and flora [14]) requires competent authorities to consider or review planning permission and other activities affecting a European designated site where the integrity of the site could be adversely affected. The Directive also

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provides for the control of potentially damaging operations, whereby consent may only be granted once it has been shown through appropriate assessment that the proposed operation will not adversely affect the integrity of the site. The responsibility lies with the applicant to demonstrate that there is no adverse effect on such a conservation area. For this purpose, biomonitoring is well suited as a non-intrusive form of environmental assessment.

As an important element within its integrated environmental policy, in 2003 the European Commission adopted a European Environment and Health Strategy ([15]) with the overall aim of reducing diseases caused by environmental factors in Europe. In Chapter 5 of this document it is stated that the “community approach entails the collection and linking of data on environmental pollutants in all the different environmental compartments (including the cycle of pollutants) and in the whole ecosystem (bio-indicators) to health data (epidemiological, toxicological, morbidity)”. The European Environment and Health Action Plan 2004-2010 ([16]) which followed the adoption of this strategy focusses on human biomonitoring, but emphasizes the need to “develop integrated monitoring of the environment, including food, to allow the determination of relevant human exposure“.

0.3 Biomonitoring with *in situ* mosses

Mosses in the strict sense are non-vascular plants belonging to the *Bryophyta* phylum. They are composed of a leafy stem (or gametophyte) bearing reproductive organs and one or more sporophytes, made up of a capsule attached to the end of a stalk that grows out of the gametophyte. According to the morphology of the moss and the position of the sporophytes, mosses are sorted into the pleurocarpous or acrocarpous main types.

For most mosses, the lack of roots, vascular system, or protective cuticle means that water and nutrients come mainly from dry, wet and occult deposition. Therefore contaminant levels in tissues of terrestrial mosses originate mainly from the atmosphere. The high surface-to-volume ratio, the large contact surface due to many leaves overlapping around the stem, as well as thin leaves (made of a single cell-layer), enable mosses to trap particles efficiently. As a result, particulate and dissolved air contaminants are taken up and retained by mosses, either on leaf surfaces or inside moss tissues. For these reasons, terrestrial mosses have been commonly used in air monitoring programmes as bioaccumulators of a wide range of atmospheric contaminants, particularly mineral compounds and elements, especially metals but also organic substances (persistent organic pollutants) and radioactive isotopes ([17], [18]).

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1 Scope

This European Standard describes the sampling protocol and the preparation of samples of *in situ* mosses to monitor the bioaccumulation of atmospheric contaminants.

This European Standard specifies the actions that shall be taken from the field sampling of mosses to their final preparation before analysis for targeted contaminants.

This European Standard is of interest to all operators wishing to conduct air quality biomonitoring studies.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
biomonitoring
use of biological systems (organisms and organism communities) to monitor environmental change over space and/or time

Note 1 to entry: Biological systems can be further considered as bioindicators.

2.2
bioindicator
organism or a part of it or an organism community (biocoenosis) which documents environmental impacts

Note 1 to entry: It encompasses bioaccumulators and response indicators.

2.3
bioaccumulator
organism which can indicate environmental conditions and their modification by accumulating substances present in the environment (air, water or soil) at the surface and/or internally

2.4
response indicator
effect indicator
organism which can indicate environmental conditions and their modification by either showing specific symptoms (molecular, biochemical, cellular, physiological, anatomical or morphological) or by its presence/absence in the ecosystem

2.5
acrocarpous moss
moss with gametophyte producing sporophyte at apex of a stem or main branch, which generally grows erect in tufts (rather than mats) and are sparsely or not branched

[SOURCE: Bibliographical reference [19], modified — The definition has been grammatically changed so that it can replace the term in context.]

2.6
pleurocarpous moss
moss producing sporophytes laterally from a perichaetial bud or a short specialized branch rather than at the stem tip

Note 1 to entry: With stems usually prostrate, creeping and freely branched moss growing in mats rather than tufts.

[SOURCE: Bibliographical reference [19]]

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