LEARNING TOXICOLOGY THROUGH OPEN EDUCATIONAL RESOURCES

ENVIRONMENTAL QUALITY AIR MONITORING

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1. INTRODUCTION

Module 6, Topic 4, is about "Monitoring Environmental Quality. Air, Water, Soil" and contains the following units:
Unit 1 – Air quality monitoring;
Unit 2 – Waters quality monitoring;
Unit 3 – Soils quality monitoring;
Unit 4 – European Environment Agency.

This topic presents the following subjects:
- specific sampling and sample pre-treatment requirements for air, waters and soils samples
- standard analytical methods available for pollutants measurements in air, waters and soils samples
- reporting the results obtained from air, water and soil monitoring
- European Union regulations concerning the assessment of air, water and soil quality
- European institutions involved in the environmental monitoring

At the end of all four units, students will be able to:
- use the available regulation about the quality indicators of air, waters and soils
- describe how can be determined the toxic compounds present in air, water and soil samples
- use the information from the available European standards for sampling and analytical methods for the determination of the environmental quality parameters
- present the European institutions involved in the environmental monitoring
- select adequate information on the environmental quality and comment relevant environmental monitoring results available on European institutions websites

The first unit, U1, "Environmental Quality. Air Monitoring" will present:
- specific sampling and sample pre-treatment requirements for ambient / atmospheric air samples;
- standard analytical methods available for pollutants determination present in atmospheric air;
- EU regulations concerning the assessment of ambient air quality.

As learning outcomes, we proposed that, at the end of the Unit 1, students will be able to:

- describe how can be determined the toxic compounds present in the atmospheric air;
- use the available regulation containing the accepted concentration limits of the pollutants in atmospheric air.

2. AIR SAMPLING

For this course / unit, the following types of atmospheric air samples, at immissions level, will be of interest:

- air with gaseous components, including particulate matter (PM);
- rain drops, clouds, aerosols, or smoke.

Gaseous emissions are not the subject of this unit.

Air is a complex matrix, with variations of composition and heterogeneity at the same location. Atmospheric pollutants concentration may differ with changes in meteorological conditions, like wind, temperature, pressure, precipitation, moisture. Therefore, it is important to ensure that the collected air sample is representative.

On the other hand, air sample amount depends on:

- the minimum pollutant concentration that can be detected / sensitivity of the analytical method
- sample size may be determined by trials; for example, 10 m^3 of air may be required to determine pollutants concentrations.

Instruments and devices available for sampling atmospheric air may be of two categories, depending on the measurement mode:

a. automated air monitoring stations are equipped with continuous air collection devices, direct-reading instruments that provide real-time data on the pollution level;
b. for the samples to be analysed in the laboratory instruments are special containers (of glass, Teflon, steel), pumps and filters (for suspended particulate matter collection) and sorbents deposited in tubes, columns, filters or cartridges.

The installation used for *passive sampling* is equipped with an absorbent (Figure 1.). Sampling duration varies between several weeks to several months.

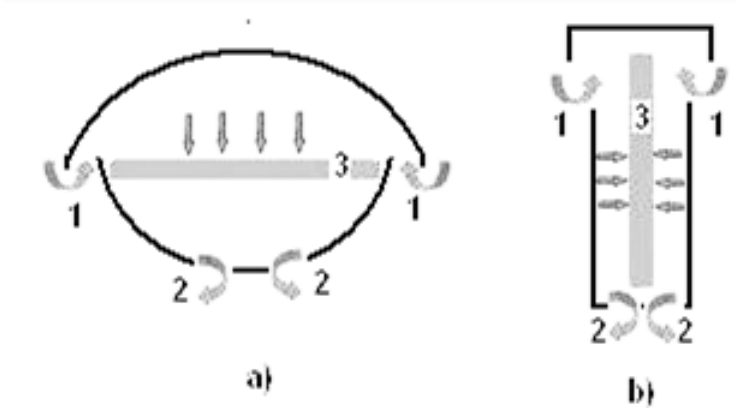

Figure 1. Passive air sampling: a) planar system; b) axial system; 1 – air inlet; 2 – air outlet; 3 – sorption material.

For *active air sampling,* in addition to the absorbent material, an air-suction pump is also used for the air removal (Figure 2).

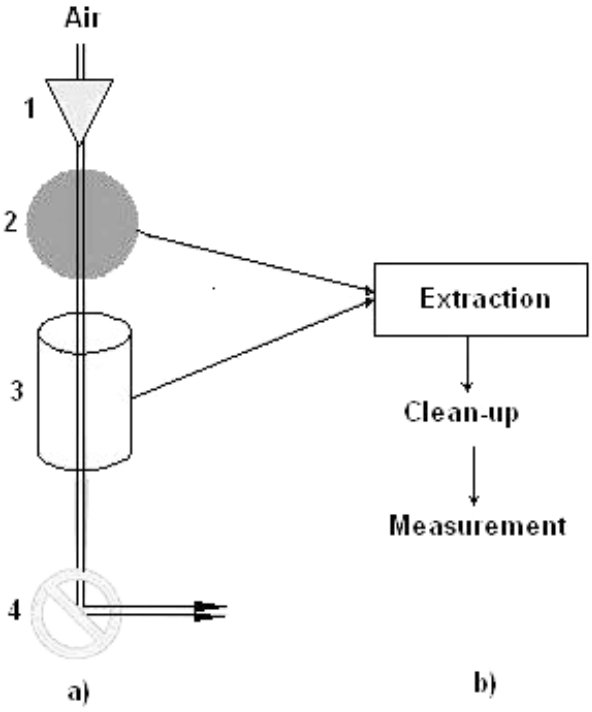

Figure 2. Active air sampling: a) sampling: 1 – sample inlet; 2 – filter; 3 – sorption material; 4 – aspiration pump; b) sample preparation and measurements.

In both cases, the sorbent materials are transferred to the laboratory for sample preparation and measurements.

The air samples collection is based on physical or chemical processes. The physical processes involved in the sampling may differ, depending on the type of compounds of interest, such as:

- gaseous and non-volatile compounds are collected based on: absorption / adsorption; absorption is followed by desorption, with solvents or thermal.
- volatile compounds are up-taken by condensation in cooling systems.

Chemical-based processes are using substrates treated with different chemical reagents, or are based on derivatization. This consists in the chemical transformation of pollutants of interest into compounds with new properties, more suitable for the detection systems. The chemical transformation stage is then followed by physical processes, to bring the samples into a measurable form.

3. AIR QUALITY PARAMETERS ASSESSED IN MONITORING STATIONS

For the air quality evaluation, occurring in the monitoring stations, the following are air quality parameters, as regulated UE Directive 2008/50/EC concerning the assessment of ambient air quality, amended with Directive 2015/1480:

- SO_2, CO, O_3
- Pb
- benzene
- NO_x (NO, NO_2) as sum of the volume mixing ratio of NO and NO_2 expressed in units of mass concentration of NO_2 ($\mu g/m^3$);
- PM_{10} – particulate matter which passes through a size-selective inlet, with a 50 % efficiency cut-off at 10 µm aerodynamic diameter
- $PM_{2.5}$ – particulate matter which passes through a size-selective inlet, with a 50 % efficiency cut-off at 2.5 µm aerodynamic diameter.

According to UE Directive 2008/50/EC (amended with Directive 2015/1480) the air quality monitoring parameters have different assessment thresholds, with upper and lower limit values. Table 1. presents the requirements for assessment specific to each air quality indicator, without the accepted threshold values.

For example, nitrogen oxides are evaluated both as hourly and annual averages, while several heavy metals adsorbed on particulate matter and benzene are assessed only as annual averages.

Table 1. Air quality indicators and the assessment requirements.

Air quality indicator	Assessment requirements	
SO_2	health protection	
NO_x (NO, NO_2)	hourly limit value for the protection of human health	annual limit value for the protection of human health
$PM_{2.5}$ and PM_{10}	24-hour average PM_{10}	annual average
Pb (Cd, As and Ni, in PM_{10})		annual average
benzene		annual average
CO	eight-hour average	

Table 2. presents the standard methods to determine the quality parameters in the air monitoring stations, also according to the above-mentioned UE Directive.

Table 2. Air pollutants standard methods, according to UE Directive 2008/50/EC (amended with Directive 2015/1480).

Air quality indicator	Standards*	Analytical method
SO_2	EN 14212:2012	UV fluorescence
NO_x (NO, NO_2)	EN 14211:2012	chemiluminescence
$PM_{2.5}$ and PM_{10}	EN 12341:2014	gravimetric
Pb (Cd, As and Ni, in PM10)	EN 14902: 2005	atomic adsorption spectrometry (AAS)
benzene	EN 14662-3:2005	gas chromatography
CO	EN 14626:2012	IR spectroscopy
O_3	EN 14625:2012	UV photometry

* EN – European norms

The standards are European norms and are based on different analytical methods. For example, PM_{10} and $PM_{2.5}$ are determined gravimetrically, heavy metals by atomic absorption spectrometry, and benzene by gas chromatography.

In addition to the air quality indicators surveyed in the monitoring stations, other compounds of interest to air quality can also be determined, especially for research based monitoring.

Thus, different species of inorganic or organic origin, with small or medium molecular weight present in atmospheric air can be determined, such as:

- inorganic gases: NOx, SO_2, SO_3, CO_2, CO, O_3;
- volatile organic compounds (VOCs), or inorganic ones;
- non-volatile organic compounds adsorbed on solid particles, like persistent organic pollutants (POPs);

– soluble compounds in the atmospheric water, like inorganic anions (NO_3^-, NO_2^-, S^{2-}, Cl^-), organic anions (formate, acetate) and metallic cations.

Besides the standard analytical methods, used according to the regulations for certain air quality parameters, other non-standard analytical methods for any pollutant of interest are also available and accepted in the laboratory practice. Both categories of analytical methods are subject to laboratory validation and accreditation, according to the ISO/IEC 17025:2005, with the recent revision, ISO/IEC 17025:2017.

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