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MILENA JOVAŠEVIĆ-STOJANOVIĆ[1]
SNEŽANA MATIĆ-BESARABIĆ[2]

[1]Radiation and Environmental Protection Department, Vinča Institute of Nuclear Sciences, P. O. Box 522, 11001 Belgrade, Serbia

[2]Institute of Public Health of Belgrade, Bulevar Despota Stefana 54 a, 11000 Belgrade, Serbia

SCIENTIFIC WORK

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# COMPARISON OF EU FRAMEWORK AND DAUGHTER DIRECTIVES AND CURRENT SERBIAN LEGISLATION ON AIR POLLUTION MONITORING

*This paper discusses the air quality control in the current legislation of the Republic of Serbia and compares it with the relevant EU legislation, Framework and Daughter Directives of the air quality monitoring and management. QA/QC components, instrumentation and methodologies of the air quality control in RS are not yet structured and harmonized with EU requirements. The limit and target values for air pollutants notified in EU legislation may be partly comparable with relevant requirements in RS legislation.*

*Key words: air quality control, monitoring, limit values, QA/QC, EU legislation.*

Air pollutants are substances which may harm humans as well as animals, vegetation and materials [1]. The health effects of the ambient air pollution have been growing in recent years. Although there are a number of questions that are still open, many epidemiological studies have demonstrated the importance of the air pollution as a risk factor for mortality and morbidity among adults and children. Recently published results of the studies and the projects in which the health impact of 20 main risk factors are ranked, also included the outdoor air pollution [2,3] with a strong focus on mortality. The burden of the combustion-related urban air pollution in developed countries was estimated to exceed the impact of other considered environmental factors [4]. Although the hazardous properties of many common pollutants are still under the intensive research there are numerous evidences of health effects associated with the exposure to air pollutants including the evidence summaries in Table 1 [5]. Significant reductions in the concentrations of some air pollutants in Western Europe and other countries, as for example lead in the past decades, demonstrate meanwhile that the improvements are possible and effective. The improving air quality has been one of the success stories of environmental policy in EU.

Following the adoption of the air quality Framework Directive [6] the European Commission has come with proposals for series of new air quality objectives to protect human health and ecosystems notified in Daughter Directives. The general aim of this Framework Directive is to define the basic principles of a common strategy to [6]:

– define and establish the objectives for ambient air quality in the Community designed to avoid, prevent or reduce harmful effects on human health and the environment as a whole,

– assess the ambient air quality in Member States on the basis of common methods and criteria,

– obtain the adequate information on ambient air quality and ensure that it is made available to the public, inter alia by means of alert thresholds and

– maintain the ambient air quality where it is good and approved in other cases.

Although the integral Law on Environmental Protection [11] came in force few years ago, the legal basis for establishing the contemporary air pollution monitoring system in the Republic of Serbia (RS) has been based on the old Law on Environmental Protection [12]. It is expected that the air quality monitoring and management in RS will be more harmonized with EU after the Law of Air Protection, which is in procedure, has been adopted.

Corresponding author: Milena Jovašević-Stojanović, Radiation and Environmental Protection Department, Vinča Institute of Nuclear Sciences, P. O. Box 522, 11001 Belgrade, Serbia.
E-mail: mjovst@vin.bg.ac.yu
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## THE OVERVIEW OF THE AIR QUALITY MONITORING SYSTEM IN RS

Current regulations on the air quality control consist of Regulation on Imission Limit Values, Imission Measurement Methods, Criteria for Setting up Measurement Points and Data Recording [13, 14] and the Program of Air Quality Control that is updated every two years [15]. The first document established limit values, threshold alert and episodic pollution criteria for notified substances. Limit values are different for urban areas, uninhabited areas and recreation areas. Substances are grouped as inorganic and organic substances, heavy metals (HM) in total suspended particulate (TSP) and carcinogenic substances. Permanent air pollution measurements in the monitoring network in urban areas are performed during one-year period. Indicative measurements should last six months or less, in the vicinity of the point pollution sources and at dense traffic roads. The minimal capturing period is 1 h for gases and 24 h for TSP. For the measurement methods, notified in the annex of the regulation, there are described procedures for sampling, analysis and levels of accuracy. The height of the sampling sites is between 1.5 and 10 m above the ground level. The results of the measurements are reviewed monthly and annually as average concentrations, characteristic percentiles ($C_{50}$, $C_{95}$ and $C_{98}$) and number of days that are exceeding the limit values.

*Table 1. Important health effects associated with exposure to different air pollutants [5]*

| Pollutant | Effect related to short-term exposure | Effect related to long-term exposure |
|---|---|---|
| Particulate matter | Lung inflammatory reaction<br>Respiratory symptoms<br>Adverse effects on the cardiovascular system<br>Increase in medication usage<br>Increase in hospital admissions<br>Increase in mortality | Increase in lower respiratory symptoms<br>Reduction in lung functions in children<br>Increase in chronic obstructive pulmonary disease<br>Reduction in lung function in adults<br>Reduction in life expectancy, owing mainly to cardiopulmonary mortality and probably to lung cancer |
| Ozone | Adverse effects on pulmonary function<br>Lung inflammatory reactions<br>Adverse effects on respiratory symptoms<br>Increase medications usage<br>Increase in hospital admissions<br>Increase in mortality | Reduction in lung function development |
| Nitrogen dioxide[a] | Effects pulmonary function, particularly in asthmatics<br>Increase in airway allergic inflammatory reaction<br>Increase in hospital admissions<br>Increase in mortality | Reduction in lung function<br>Increased probability of respiratory symptoms |

[a]In ambient air nitrogen dioxide serves as an indictor for the complex mixture of mainly traffic related air pollution

The monitoring of the immision given in the Program of Air Quality Control was performed by two monitoring systems: (a) the basic network of hydrometeorological stations and (b) the local urban monitoring network. The National Hydrometeorological Institute performs programs of air monitoring at their stations as part of the network of 27 meteorological stations and urban meteorological stations where they measure air pollutants ($SO_2$, $NO_2$, $O_3$, soot and green house gases) and precipitation (cations, anions and heavy metals). The measurements performed at the local urban monitoring network are performed by the Municipal Health Institutions or Centers. According to current Program [15] there are 82 measuring stations, sampling sites, in the local urban network of monitoring stations in 43 cities. At local urban monitoring network the major air pollutants (soot, $SO_2$, $NO_X$, TSP, $O_3$, CO) are collected, as well as total air deposition for the analysis of heavy metals at most of the sites. $SO_2$ and soot have been captured at almost all and $NO_2$ at most sites. There are also mandatory measurements of specific pollutants for the purpose of the control of air pollutants from the industrial sources at 45 measuring stations in 23 cities. The Program includes the control of next specific pollutants, between 2 and 14 specific pollutants being collected per site: PAH, acrolein, $NH_3$, HCl, $H_2S$, phenol, benzene, toluene, xylene, Pb, Cr, Ni, Cd, As, formaldehyde, $CS_2$, Hg, total HC, mercaptane, atrazine, HF, ethyl acetate, Mg, $CO_2$, Zn, Al, methanol.

## COMPARISON OF SOME COMPONENTS OF AIR QUALITY MANAGEMENT IN EU AND RS

The adoption of the Framework and Daughter Directives on the ambient air quality assessment and management [6-10] in the EU, introduced a number of useful changes that improved the quality assurance and control (QA/QC) of the ambient air monitoring. QA/QC of the ambient air quality monitoring is a set of

measures that enable accurate, precise, credible and time consistent measurements; representative data of the ambient air pollution; the results that are comparable; high data sampling, evenly distributed; the optimal use of resources; etc [16]. It also encompases other components, QA/QC covers a network design, a sampling site selection, the method of sampling and the analysis selection, the equipment selection. The criteria of the air quality control were set, giving limit values and concentrations for an averaging period that represents the acceptable level of pollutants in ambient air.

Framework and Daughter Directives introduced the concept of zones, with agglomeration that are special zone types with more than 250000 inhabitants. Zones are basic territorial units where the compliance of limit values should be checked, as well as a regime for monitoring. To demonstrate the compliance with the limit values, monitoring should be performed by measurement or modeling. The most stringent regime is where maximum concentrations are above 70 % of limit values and the least stringent regime is in a zone where the maximum concentrations are below 50 % of the limit value [17]. Depending on the established regime in the zone, high quality measurement, a modeling technique, the objective estimation or indicative measurement is performed.

In RS territories, a local urban monitoring network coincides with municipalities but different monitoring regimes are not strictly recognized. In RS legislation, there are proposed mandatory measurements and also the measurements lasting six months or less to obtain data in busy traffic streets and areas where several air pollutant sources are located. The last measurement has some elements of preliminary and supplementary measurements in Member States, but they are not defined and performed in an equivalent manner.

## NETWORK DESIGN

The EC Daughter Directives give proposals for a number of fixed sampling points of pollutant measurements for diffusive sources depending on the population of the agglomeration or the zone and the concentration of the pollutant. The number of sampling points in the vicinity of point sources should be calculated taking emission densities into account and the potential exposure of the population. In RS the number of sampling points is established according to the annual program [15]. It establishes a number of sites for major and specific air pollutants. Bearing in mind that $SO_2$ is captured at almost all sites it seems that there are enough fixed sites for measuring such air pollutant taking into account the criteria for determining the minimum number for fix measurements according to the EC Daughter Directive. Soot is also captured at all 60 sites in RS. Program [15] proposes capturing $NO_2$ at 64 sampling points and TSP at 69 sites (HM including Pb are analyzed from TSP), $O_3$ at 11 and CO at 8 points. In current regulation in RS the monitoring of benzene is proposed in 12 towns. A diffusive point monitoring has not yet been established. The distribution and number of sampling points for the measurements of pollutants from point sources need to be remodeled in RS legislative, taking into account a wide range of air pollutants.

The Daughter Directives describe the framework for macroscale and microscale location of the sampling points. There are same specific rules about the macro-scale and the micro-scale location of capturing particular air pollutants, which include selecting representative locations that would give characteristics of the air pollution in urban, curbside, industrial, residential and rural areas. In current RS Regulation [13] the establishing of a sampling point would depend on the characteristics of the area where air pollution would be controlled, the distribution and the type of the sources, the density of the population, orography and meteorological conditions. There are other requirements that specify a site selection, although limit values are specified for urban, uninhabited and recreation areas.

The main part of the air pollution monitoring system in Member States (MS) as well as in other developing countries is the network of the automatic monitoring stations. In RS the automatic monitoring stations have been established only in Belgrade (3 sites), Pančevo (2 sites), Bor (2 sites), Smederevo (2 sites) and Zrenjanin (1 site). Such sites are established through different programs and they are part of local municipal or industrial monitoring systems and they do not belong to a monitoring system of RS. It may be emphasized that the automatic monitoring of PM10 is performed only at seven sites in RS: four sites in Belgrade, two sites at Pančevo and one site in Zrenjanin. In the period to come 25 automatic monitoring stations will be installed all over the RS at present locations of the basic network of meteorological stations. The equipment will be procured in the framework of ongoing CARDS program.

## MONITORING METHODS

In developing countries, the basic rule for choosing monitoring methods for the air pollution control is the availability of the equipment and a limited level of

financial assistance. Monitoring methods that may be recognized in RS regulation are only the active sampling methods [13], while passive samplers, continual monitoring methods (automatic analysers and remote sensors), modeling and the objective estimation do not exist in the regulations. It is well known that the simplest methods that meet monitoring objectives should always be selected. There are numerous situations where it would be possible to use diffusive (passive) sampling or only modeling tools. Automatic, continual monitoring may also be necessary under defined requirements. The diffusive sampling method has been adopted in MS and many other countries all over the world, but in RS it has not been included either in regulations or in the practice of the air pollution quality control. The only case where a diffusive sampling method was applied is in Pančevo. That project has been performed by the Institute for Air Pollution from Rome, Italy, and funded by the Italian Ministry of Environmental Protection.

Table 2 presents sampling media and methods of air pollutant analysis that was used in RS in comparison with the reference methods adopted in EC Daughter Directives.

*Table 2. Methods of sampling and analysis of air pollutants due to RS and EU regulation*

| Air pollutant | Sampling media | Republic of Serbia | | EU | |
|---|---|---|---|---|---|
| | | Analysis | Relevant Standard | Analysis | Standard |
| $SO_2$ | Acidimetric<br>Tetrachloromercurate<br>Thorin method | Spectrophotometer | ISO 4220<br>ISO 6767<br>ISO 4221 | Fluorescence | EN14212 |
| $NO_2$ | Wet method with solution of trietanolamin | Modified Griess-Saltzman method | ISO 6768 | Chemiluminescence | EN14211 |
| CO | Sampling bag or continual capturing | IR spectrometry | - | Non-dispersive IR spectrometry | EN14666 |
| $C_6H_6$ | Sampling bag | GC | VDI 2453 Provisional ISO 8 | GC | EN14662 parts 1-3 |
| SPM | Fibreglass membrane filter | Derenda Gravimetric | - | - | |
| $PM_{10}$ | β absorption FH 621-R Horiba 2002 EPA &TÜV/UBA | | | PM10 reference sampler (EN12341) | EN12341 |
| Pb, As, Cd, Ni | Fiberglass membrane filter | AAS | - | PM10 reference sampler + analysis by AAS or ICP-MS | EN14902 |
| $O_3$ | Automatic monitor | UV photometry | - | UV photometry | EN14665 |
| Benz(a)-pyrene | GF/A Whatman & PUF | GC MSD | - | PM10 reference sampler + analysis by LC-fluorescence or GC-mass spectrometry | - |
| Soot | Filter paper | Reflectometer | - | - | |

## PRESENTATION OF AIR POLLUTION DATA

Air pollution control data are analyzed monthly and annually and presented as statistical parameters and chart diagrams. According to the regulation it is necessary to have not less than 75 % of all data captured for the reporting period in comparison to 90% in EC Daughter Directives. The values of uncertainty and minimum time coverage are not defined in RS regulation.

## COMPARISON OF CRITERIA OF AIR QUALITY CONTROL IN EU AND RS

The criteria for air quality assessment in urban areas in EU are limit values used for the protection of human health (hourly, daily, yearly) and threshold values (alert and information). In the Framework Directive [6] there are established lists of atmospheric pollutants that are to be taken into consideration. In Daughter Directives [7-10] there are criteria for assessing the air quality for several pollutants: $SO_2$, $NO_2$, $PM_{10}$, Pb, CO, $C_6H_6$, $O_3$, As, Hg, Cd, Ni and PAH. Tables 3 and 4 show the limit and threshold values for the average period of air pollutants in the EC Directives and compared with relevant values in RS regulatory [13,14].

The RS critera for assessing the air quality in urban areas are partly harmonized with the EU, but only hourly the limit values for the protection of human health for $SO_2$ are the same. In the EU the number of exceedances of the $SO_2$ hourly limit value per

calendar year is 24 times. The criteria that has the same limit value but a different average period is the hourly limit value for the protection of human health for CO. The average period in EU is 8 h and in RS regulations it is 1 h. There are some criteria where the average period is the same, but the limit values are different. The limit and target values, as well as the reference period for HM and Benz(a)pyrene are same. The question is, could the results be compared: in RS the sampling of TSP is performed while in EU it is the sampling of PM10.

*Table 3. Limit values in EU and RS regulations for protection of human health*

| Compound | EU | | | RS | |
|---|---|---|---|---|---|
| | Limit value μg/m$^3$ | Reference period | Number of exceedance of per year | Limit value μg/m$^3$ | Reference period |
| $SO_2$ | 350 | 1 h | 24 | 350 | 1h |
| | 125 | 24 h | | 125 | 24 h |
| | 20 | 1 y | | 50 | 1 y |
| $NO_2$ | 200 | 1 h | 18 | 150 | 1h |
| | 40 | 1 y | | 85 | 24 h |
| | 30 | 1 y | | 60 | 1 y |
| CO | 10000 | 8 h | - | 5000 | 24 h |
| $C_6H_6$ | 5 | 1 y | - | 5 | 1 y |
| TSP | - | | | 120 | 24 h |
| $PM_{10}$ | 50 | 24 h | 35 | - | |
| | 40 | 1 y | | | |
| Pb | 0.5 | 1 y | - | 1 | 24 h |
| soot | - | | | 50 | 24 h |

*Table 4. Target values in EU and releveant values in RS regulations for protection of human health*

| Compound | | EU | | RS | |
|---|---|---|---|---|---|
| | | Threshold value, μg/m$^3$ | Reference period | Threshold value, μg/m$^3$ | Reference period |
| $NO_2$ | | 400 | 3 h | 300 | 1h |
| | | 40 | 1 y | 85 | 24 h |
| | | 30 | 1 y | 60 | 1 y |
| CO | | 10000 | 8 h | 10000 | 1 h |
| $O_3$ | Long term objectives | 120 | 8 h | - | - |
| | Alert treshold | 240 | 1 h | 200 | 1 h |
| | Information alert | 180 | 1 h | - | - |
| Benz(a)pyrene | | 0,001 | 1 y | 0,001 | 1 y |
| As | | 0,006 | 1 y | 0,006 | 1 y |
| Cd | | 0,005 | | 0,005 | |
| Ni | | 0,020 | | 0,020 | |

## CONCLUSION

Between 1996 and 2004 EU has adopted the Framework and four Daughter Directives of the air quality control that replaced the old generation of directives from the eighties, where there were new elements in QA/QC involved. The basic concept of the new approach consists of the Framework Directive for air pollutants and Daughter Directives for particular groups of pollutants. The legislation of the air quality control in the Republic of Serbia is going to be replaced with new laws and regulations which will be harmonized with the current EU QA/QC structure and practice. We need to harmonize alert limit and threshold values where they are higher than in the EU. More extensive assessment requirements would be involved. Methods of measurements, sampling and analyzing pollutants need to take into account the procedures proposed in relevant EN standards (Table 2). Air quality monitoring, a direct measurement of the air quality is an important part of the urban air quality assessment program and still it does not exist in RS re-

gulation and practice. For the improvement of the air quality monitoring it is necessary to establish a complete emission inventory as well as to use more air pollution modeling techniques. It is also necessary to include the indicative methods of measuring like diffusive sampling methods for indicative and supplementary measurements. One of the priorities should be to capture respirable aerosols, aerosols less than 10 μm. The limit and target values for HM are the same in EU and RS, but they are not comparable as TSP is sampling in RS and control of PM10 is still not involved. One of the main differences that RS air quality monitoring has to harmonize with EU is the sampling and control of PM10 and the analysis of the quantity of HM and benz(a)pyrene in the appropriate manner from PM10.

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