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ADAPTATION OF MONITORING NETWORKS IN EASTERN EUROPE, CAUCASUS AND CENTRAL ASIA: AIR QUALITY MONITORING

Report by the secretariat

SUMMARY

The report assesses air quality monitoring networks in Eastern Europe, Caucasus and Central Asia (EECCA), including monitoring densities, the parameters measured, the reliability of measurements and analysis, air quality standards, data management and reporting and networks modernization programmes and plans. It describes the requirements of relevant multilateral environmental agreements, guidelines, standards and manuals developed by international organizations, and approaches to and experiences in developing air quality monitoring in the European Union and the United States.

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INTRODUCTION

1. According to its revised mandate, the Working Group has, among other things, to appraise national environmental monitoring requirements in order to strengthen monitoring networks. It also has to outline compatible monitoring standards and formats in order to enhance the international comparability of environmental information. Consistent with these goals, the Working Group, at its fifth session in 2005, decided to assess existing environmental monitoring networks in EECCA in order to advise on priority needs for expanding, upgrading and optimizing these networks, taking into account international requirements, guidelines and experiences (CEP/AC.10/2005/2, annex).

2. At its sixth session, the Working Group is expected to start the appraisal by focusing on air quality monitoring in EECCA. This report is intended to facilitate the discussion. It reviews the situation in EECCA with regard to local, background and transboundary air quality monitoring on the basis of information collected and analyses made by the secretariat under the recent UNECE environmental performance reviews of EECCA countries,[1] country environmental pollution reports,[2] communications from EECCA countries[3] to the secretariat and recent reports by the World Health Organization (WHO)/Europe.[4]

3. Section I describes the current EECCA networks that are primarily designed to measure local air quality with a focus on human health. Section II highlights opportunities to contribute to international networks that monitor background concentrations and regional trends, and to upgrade air quality and air monitoring standards in accordance with relevant international guidelines. Section III considers monitoring carried out in the European Union and the United States.

I. MAIN FEATURES OF CURRENT EECCA NETWORKS

A. Measurement programmes

4. Existing air quality monitoring networks in EECCA countries were generally established in the 1970s and 1980s. Measurement programmes conformed to the former USSR standard of 1986,[5] which established four types of measurement programmes:

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[1] *Environmental Performance Review No. 19 – Azerbaijan*, Sales No. E.04.II.E.2; *Environmental Performance Review No. 21 – Tajikistan,* Sales No. E.05.II.E.3; *Environmental Performance Review No. 22 – Republic of Moldova* (forthcoming); *Environmental Performance Review No. 23 – Belarus. Second review* (forthcoming); *Environmental Performance Review No. 24 – Ukraine. Second review* (in progress).
[2] *Review of Environmental Pollution in the Russian Federation in 2004* (in Russian). Roshydromet. Moscow, 2005.
[3] Armenia, Belarus, Georgia, Kyrgyzstan, Republic of Moldova, Russian Federation, Ukraine and Uzbekistan.
[4] *Health basis for air quality management in Eastern Europe, Caucasus and Central Asia*. Report from a WHO consultative meeting Moscow, Russian Federation. WHO/Europe. 30-31 May 2005; *Air Quality and Health in Eastern Europe, Caucasus and Central Asia*. Report on the WHO Workshop. Saint Petersburg, Russian Federation, 13–14 October 2003. WHO/Europe, 2003.
[5] GOST 17.2.3.01-86 "Environmental Protection. Atmosphere. Rules for Monitoring Air Quality in Human Settlements" (in Russian).

a) Complete programmes with measurements (of over 20 minutes) four times a day (at 1 a.m., 7 a.m., 1 p.m. and 7 p.m.) to assess single-measurement/single-interval concentrations and 24-hour concentrations of polluting substances in the air;
b) Incomplete programmes with measurements three times a day;
c) Reduced programmes with measurements twice a day; and
d) Programmes of continuing measurements.

5. In practice, most fixed measurement stations in EECCA have incomplete or reduced programmes. The monitoring is based on manual sampling. There are very few automated monitors. There are 57 automated stations in the Russian Federation operated by city authorities, with the Cities of Moscow and Saint Petersburg operating 28 and 15 stations, respectively. The Ministry of Health and Social Protection of the Republic of Moldova operates four automated monitors, and Belarus has one such station.

B. Monitoring site locations

6. In most countries, monitor locations and sampling and analytical methods follow the *Guidelines on Air Pollution Monitoring*[6] established in the former USSR in 1989. In the Russian Federation and some other countries, the 1991 (revised) version[7] of these *Guidelines* is used. The *Guidelines* determine the minimum number of sampling points for measurement of concentrations of pollutants in urban areas. They require that there be one fixed sampling point per 50,000–100,000 city dwellers. Almost all the stations are concentrated in densely populated and highly industrialized cities. There is no obligation to have fixed sampling points in urban areas with low pollution levels. As a result, some 35 per cent of city dwellers in both Belarus and the Russian Federation, for instance, live in areas without fixed sampling points.

7. The main criterion followed in establishing station locations is to cover the maximum possible number of inhabitants, considering that each station is representative within a radius of up to 5 km. Most of the monitoring stations are therefore located in residential areas, and consequently give a good indication of the population’s exposure to air pollution without always capturing the full impact of pollution episodes. The existing air observation networks in most EECCA countries have not been reviewed or revised since their inception.

8. Ukraine has maintained and Belarus and the Russian Federation have even somewhat increased the total number of fixed sampling points over the past 10 years. In other countries, monitoring networks have contracted over the same period. Networks have suffered most in Georgia and Tajikistan. Seventeen air-quality monitoring posts were destroyed during the civil war in Tajikistan. Consequently, air quality is no longer monitored in five cities.

9. Overall, the current ambient air monitoring networks in EECCA do not meet the requirements of current national regulations. For instance, in Belarus there should be 15 stations instead of the current 11 stations in Minsk and 5 (instead of 4) in Gomel. Furthermore, there should be at least one monitoring station each in Baranovichi, Borisov, Lida and Zhlobin. In the Republic of Moldova there should be two more stations in Chisinau and one more in Cahul.

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[6] *Guidelines on Air Pollution Monitoring RD 52.04. 186-89* (in Russian).
[7] *Guidelines on Air Pollution Monitoring RD 52.04. 186-91* (in Russian).

10. The stationary measurements are supplemented by mobile sampling and analyses in some countries to detect pollution peaks caused by local industry. For instance, in Belarus the Ministry of Natural Resources and Environmental Protection operates a few mobile laboratories to measure air quality in areas close to polluting enterprises and major roads, as well as in recreation areas.

11. In addition, at meteorological stations in several EECCA countries precipitation chemistry and snow samples are analysed to determine acidity and nitrate, ammonia and heavy metals content. Precipitation stations are distributed throughout the countries' territories, away from industrial centres. Observations regarding the chemical composition of precipitation are based on the total monthly sampling of rainwater. Sampling of snow cover is carried out once a year during the period of maximal snow accumulation.

12. Annex I to this report presents the density of various fixed air monitors in EECCA.

C. Measured parameters

13. Measured parameters for fixed sampling points generally follow the priority list of hazardous substances established in 1983,[8] which covers 19 polluting substances divided into basic substances (total suspended particulates, sulfur dioxide, carbon oxide and nitrogen dioxide) and specific substances (formaldehyde, benzo(a)pyrene, fluorides, mercury, hydrogen fluoride, solid fluorides, iron, cadmium, cobalt, magnesium, manganese, copper, nickel, lead, chromium and zinc). At the same time, according to the *Guidelines on Air Pollution Monitoring*, the selection of specific parameters for a fixed sampling point should take into account emission patterns in the urban area, the size of the area and its air diffusion capacity. As a result, the total number of parameters measured in EECCA varies from 7 to 33 (see Annex I).

14. Monitoring networks in EECCA suffered in the 1990s from various difficulties caused primarily by underfinancing. Reductions in sampling periodicity, decreases in the reliability of measurements due to aging equipment and a lack of basic supplies affected many parts of the subregion. For instance, owing to the lack of resources, in Azerbaijan only 70 per cent of the planned air pollution samples and 45 per cent of the planned precipitation samples were taken in 2003. The national inventory of air monitoring devices in use in Ukraine lists equipment dating back to 1946. Many stations, especially in Armenia, Georgia, Kyrgyzstan, the Republic of Moldova and Tajikistan, today measure only a limited number of meteorological and chemical parameters (SO_2, NO_x, dust, CO, B(a)P and Pb) in urban air, as a consequence.

15. There are practically no regular measurements of ground-level ozone concentrations (O_3) in EECCA countries except at a few stations in the Russian Federation, two stations in Belarus and one station in Uzbekistan. There are barely any measurements of fine suspended particulates, such as PM_{10} or $PM_{2.5}$ (particles smaller than 10 and 2.5 microns, respectively), which are known to have the most serious impact on human health. City authorities in Moscow started regular monitoring of PM_{10} in seven locations (considered to represent urban background, not directly

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[8] *Temporary Recommendations for the Preparation of a List of Hazardous Substances to Be Monitored in the Atmosphere.*Moscow, 1983.

affected by pollution sources) in 2004. In Belarus, only an integrated background monitoring station in the Berezinsky Biosphere Reserve has been measuring PM_{10}. Since early 2006 such measurements have started in Minsk and Mogilev, which have one station each.

16. There is no monitoring of dioxin/furan concentrations in ambient air in EECCA. Monitoring of volatile organic compounds (VOCs), except benzo(a)pyrene, and of persistent organic pollutants (POPs) is in the initial phase in some but not all EECCA countries. Belarus initiated VOCs monitoring in Mogilev in 2003. It monitors polyaromatic hydrocarbons (PAH) at 17 points in 12 cities. The Russian Federation regularly monitors organochlorine pesticides (DDT and hexachlorocyclohexane), some polychlorinated biphenyls (PCB), benzo(a)pyrene and benzo(ghi)perylene in the air in many cities. The Russian Federation recently monitored POPs in the air in the Russian Arctic, in Amderma in 1999–2001 and in Chukotka in 2002, within the framework of the Arctic Monitoring Assessment Programme (AMAP).

D. Reliability of measurements and analysis

17. Current sampling strategies in EECCA have many shortcomings. In general, ambient monitoring systems were designed to detect longer-term pollution trends rather than high pollution peaks and thus did not help daily air quality management. Monitoring for 20 minutes at a time two or three times a day is not effective in establishing mean or transient air quality data indicators, and it is especially unsuitable in areas where concentrations of pollutants change rapidly. The comparison of monitoring results obtained through this approach with continuous data from ad hoc automatic analysers, a procedure undertaken recently in some EECCA countries, demonstrated the variable and transient nature of pollution episodes, none of which could be effectively captured via the sampling strategies currently in use in EECCA.[9]

18. Comparison of the data from automatic, continuous analysers, for instance, showed that agreement ranged from very good to a difference of a factor of three for nitrogen dioxide. Comparisons of carbon monoxide and total suspended particulate concentrations are complicated by the fact that the results reported by monitoring stations are at the detection limits for the techniques used, whereas the automatic analysers are much more sensitive to lower concentrations. Carbon monoxide concentrations were found to be under-estimated on most occasions, and total suspended particulates were over-estimated, using the instruments used by EECCA monitoring services.

19. Comparison of lead monitoring data indicated that lead concentrations were being under-estimated by an order of magnitude or more. The reliability of measurement of lead and total suspended particulates is frequently undermined by the quality of filters that have a large pore size, extremely high sampling rates, inadequate filter conditioning methodologies and poor resolution of the equipment used to weigh the filters.

20. Samples are analysed in laboratories, as a rule, according to guidance documents of the former USSR based on photometry, mass spectrometry, chromatography and atomic absorption methods. National standardization committees (Gosstandart) operate laboratories that play a key

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[9] See, for example, *Air Quality Monitoring in Central Asia and the Caucasus*. Report for the Regional Study on Cleaner Transportation Fuels for Urban Air Quality Improvement in Central Asia and the Caucasus. Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP). 2000.

role in the accreditation procedure for other laboratories. In several EECCA countries, all equipment for environmental laboratories is being tested in a Gosstandart laboratory as part of the accreditation procedure. In accordance with the 1986 methodological guidelines,[10] accredited institutions check the accuracy of the measurements made by the national monitoring networks.

21. Quality assurance and control (QA/QC) are being slowly introduced into EECCA. Some EECCA countries, like Belarus, the Russian Federation and Ukraine, follow the development of air monitoring standards in the International Organization for Standardization (ISO) (see section II.B) and are adapting their measurement methods to some extent. In several EECCA countries there are no joint inter-calibration or training exercises; their laboratories do not participate in national or international inter-laboratory comparisons, so quality assurance and quality control are areas of concern.

E. Air quality standards

22. According to sanitary and hygienic requirements, single-interval (20 minutes) and computed daily average values are the basic toxicity measurements of substance concentrations in the air. To define a pollution level in urban areas, these values are compared with the corresponding maximum allowable concentrations (MACs) for the substance.

23. Most EECCA countries use MACs and Guiding Safe Exposure Levels established by the Ministry of Health of the former USSR 30–40 years ago. These standards are only health-based and do not take into consideration the protection of ecosystems and amenities. Some EECCA countries have recently updated and supplemented these standards. In the Russian Federation, for instance, the Ministry of Health approved a health standard[11] in 2003 listing MACs or Guiding Safe Exposure Levels for some 660 substances. Emission of 44 substances is forbidden in the Russian Federation. While an assessment of the hazards presented by such a broad range of pollutants might be justified, their comprehensive and regular control is extremely difficult and costly. Overall, the excessively large number of regulated pollutants imposes unrealistic monitoring and enforcement requirements on public authorities. National monitoring strategies of EECCA countries address only a tiny proportion of regulated pollutants.

24. EECCA standards are generally more stringent than international ones, but they are also more basic. For example, many Western countries set different standards for different sizes of particulate matter (e.g. PM_{10} and $PM_{2.5}$), while EECCA countries use the concept of total suspended particulates (TSP). Similarly, many standards for air pollutants in non-EECCA countries differ according to length of exposure (e.g. 1 hour, 3 and 8 hours, and annually), whereas EECCA standards are based on 20 minutes length of measurements and 24-hour averages. A comparison of some key EECCA MACs with the air quality limits of the European Union, the United States and WHO is presented in Annex II to this report.

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[10] *RD 52.24.268-86 Methodological Guidelines. System for Observing the Accuracy of Measurements of Pollution Levels in the Monitored Environment.*

[11] *GN 2.1.6.1338-03 Maximum Allowable Concentrations (MACs) of Pollutants in the Ambient Air of Human Settlements.*

25. Efforts have been taken in some EECCA countries recently to harmonize domestic standards with international ones. For instance, in the Russian Federation the Commission on State Sanitary and Epidemiological Standardization under the Federal Service for Supervision of Consumer Rights and Welfare is currently considering about 30 updated standards for approval.

F. Data management and reporting

26. Routine observations of atmospheric air pollution levels are carried out primarily by national hydrometeorological services. In addition, state environmental inspectorates and sanitary epidemiological inspectorates of Ministries of Health perform ad hoc air quality sampling near emission sources, main roads, sanitary protection zones and apartment blocks, as well as on the grounds of schools, preschools and medical institutions in urban areas. Although they generally measure the same pollutants, they use different equipment and methods, which makes it difficult to relate their results to those obtained by hydrometeorological services.

27. Owing to an overall lack of coordination, the results obtained from various air quality monitoring activities in a country are frequently not comparable or complementary. There is no interpretation of dose relationships between different data sets. The current air quality networks are generally unable to link air pollution levels with emission patterns and so identify activities that violate emission norms or air quality standards under normal operating conditions.

28. There is no centralized or inter-connected distributed electronic network for transmission of air monitoring data in EECCA countries. The lack of common data interpretation and exchange of air monitoring results makes a full assessment of air quality difficult. Furthermore, monitoring data are rarely used in developing environmental policy plans and programmes.

29. Ambient air quality data are frequently recorded in paper format and not in computerized databases. Data measurements are reported in paper format on a daily, monthly and annual basis. Urban air quality is widely assessed and reported in EECCA according to the so-called IZA-5 index (integrated pollution index), which records the exceeding of MACs of five pollutants that are representative for the urban area in question. Usually these are TSP, SO_2, NO_x, CO and formaldehyde. Annual mean concentrations for each of the five pollutants are used in calculating the index. The air pollution is considered “elevated” if the index is between 5 and 6, “high” if it is between 7 and 13, and “very high” if it exceeds 13. The approach does not allow air quality comparisons between cities.

G. Network modernization programmes

30. Some EECCA countries have recently prepared, or initiated the preparation of, conceptual documents or programmes to extend and modernize their air-monitoring networks. Armenia, for instance, has developed a draft monitoring concept for 2007–2010. The objective is to set up, by 2010, 53 fixed automated sampling points (including 15 in the capital) and to expand the measurement programme to ground-level ozone (O_s), ammonia (NH_s), fine particles (PM_{10} and $PM_{2.5}$), VOCs, POPs, radon and some other pollutants. There are also plans to purchase motor vehicles for mobile monitoring. Total resource requirements are assessed as some US$ 4 million. The Government of Armenia plans to earmark US$ 420,000 for upgrading

both air and surface water monitoring networks in 2007–2008. External support is needed to match the limited domestic funding.

31. Belarus is currently implementing a programme of technical modernization of its air monitoring network. It will include expanding monitoring of PM_{10} and ground-level ozone in ambient air. During 2006, ground-level ozone observations will be started at one station in Minsk, while PM_{10} measurements will be expanded in Minsk and started at one station in Gomel. By the end of 2006, VOC measurements will start in eight industrial centres. Nineteen fixed automated sampling points are planned to be set up by 2010.

32. In the Russian Federation, the hydrometeorological service has prepared a draft departmental programme to develop its monitoring networks in 2006–2008. The equivalent of some US$ 41 million will support the programme's implementation, including modernization of the air quality monitoring network. Seven times as much funding will be allocated as for the previous (2003–2005) monitoring programme.

33. In Ukraine, in 2004, the Cabinet of Ministers approved a Conception of a State Programme of Natural Environment Monitoring and pledged the equivalent of US$ 40 million for programme implementation for 2006–2010. If the programme is approved in 2006, it will be a stimulus for important activities such as the modernization of air monitoring stations, optimization of the network, and the establishment of computerized databases for multiple users.

34. In Uzbekistan, the hydrometeorological service has developed a plan to improve and modernize air monitoring. It was necessary to set up 11 automated and 28 additional non-automated fixed sampling points, to establish two additional analytical laboratories and to purchase analytical and computer equipment for existing laboratories for a total of US$ 4.15 million. Financing of the plan is not ensured.

II. MODERNIZING EECCA AIR QUALITY MONITORING NETWORKS FOR INTERNATIONAL PROGRAMMES

35. When extending and upgrading their monitoring networks, EECCA countries may take into account the requirements of relevant multilateral environmental agreements, guidelines, standards and manuals developed by international organizations as well as approaches to and experiences with developing air quality monitoring in other parts of the UNECE region. These are described briefly below.

A. Multilateral environmental agreements and programmes relating to air quality monitoring

Convention on Persistent Organic Pollutants

36. The 2001 Stockholm Convention on Persistent Organic Pollutants sets monitoring and reporting requirements at the global level for persistent organic pollutants (POPs) present in air, water, soils and sediments. This relates in particular to monitoring of polychlorinated biphenyls (PCBs), dioxins/furans and PAH in the air and precipitation. Ten EECCA countries – Armenia,

Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, the Republic of Moldova, the Russian Federation, Tajikistan and Ukraine – have signed or ratified this convention.

Convention on Long-range Transboundary Air Pollution

37. Nine EECCA countries – Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, the Republic of Moldova, the Russian Federation and Ukraine – are Parties to the 1979 UNECE Convention on Long-range Transboundary Air Pollution. The Parties have committed themselves to limiting, gradually reducing and preventing air pollution, including long-range transboundary air pollution. To combat air pollution, each Party is obliged to develop effective policies and strategies, including air quality monitoring and management systems.

38. The Convention and its eight protocols together promote, among other things, monitoring of air pollutants as follows: SO_2, NO_x, ammonia (NH_3), O_s, particulate matter (PM_{10}, $PM_{2.5}$ and total suspended particles (TSP)), nonmethane volatile organic compounds (NMVOCs), POPs and heavy metals (cadmium, lead and mercury). There are recommended methods for instrumentation and techniques for monitoring ambient concentrations of air pollutants. Protocols stress the need to exchange meteorological and physico-chemical data relating to the processes during transmission, the need to use comparable or standardized procedures for monitoring whenever possible and the need to establish monitoring stations.

39. Parties to the Convention are urged (under Executive Body decision 2004/1) to have monitoring stations to measure the quality of the air and precipitation under its Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP). EMEP focuses on air pollutants in rural and background areas to provide data to establish trends and provide validation for air pollution models. The EMEP Monitoring Strategy and Measurement Programme 2004–2009 has provided details for the scope of EMEP monitoring activities.[12] The EMEP monitoring programme is now organized with monitoring at three different levels of complexity.

40. For level I sites, the main objective of monitoring is to provide long-term basic chemical and physical measurements of the traditional EMEP parameters. Level 1 activities are the first priority when extending the network to areas not yet covered by measurements, including Eastern Europe and Central Asia. Measurements at level 1 include parameters required to describe basic aspects of particulate matter, photochemical oxidants, acidification, eutrophication and heavy metals, as well as trends over time.[13]

41. Level 2 sites provide additional parameters essential for understanding the process and for further chemical speciation of relevant components; they are an essential complement to the level 1 sites. Measurements at level 2 sites include all parameters required at level 1 plus a series of additional ones. Level 3 activities are research-oriented and are optional. The main objective

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[12] *EMEP Monitoring Strategy and Measurement Programme 2004-2009* as amended and adopted by the EMEP Steering Body at its twenty-eighth session (www.unece.org/env/emep/strategies.html).

[13] Including inorganic compounds in precipitation (SO_4^{--}, NO_3^-, NH_4^+, H^+ (pH), Na^+, K^+, Ca^{++}, Mg^{++}, Cl^- (cond)), heavy metals in precipitation (Cd, Pb (1st priority), Cu, Zn, As, Cr, Ni (2nd priority)), inorganic compounds in air (SO_2, SO_4, NO_3^-, HNO_3, NH_4^+, NH_3, (sNO_3, sNH_4), HCl, Na^+, K^+, Ca^{++}, Mg^{++}), NO_2 in air, O_3, $PM_{2.5}$, PM_{10}, Gas particle ratios (NH_3, NH_4^+,HCl HNO_3, NO_3^- (in combination with filter pack sampling)) and meteorology.

of level 3 sites is to develop the scientific understanding of the relevant physico-chemical processes in relation to transboundary pollution and its control.

42. The EMEP site density typically ranges from one to two sites per 100,000 km^2. All Parties with an area larger than 10,000 km^2 are requested to operate at least one level 1 site. Parties with an area larger than 50,000 km^2 are expected to operate at least one level 2 site.

43. Measurements should satisfy quality assurance and quality control requirements.[14] The EMEP *Manual for Sampling and Chemical Analysis* gives the criteria that need to be satisfied for instrumentation and analytical methods.

44. Only four EECCA countries currently have EMEP stations. These provide EMEP with data on nitrogen and sulphur compounds in the air and precipitation. Even in these countries the current network is insufficient. The measurement programmes at the stations do not match the requirements under the Convention. Armenia and Georgia are discussing opportunities to establish (with external support) one EMEP station each. Belarus is considering establishing three more EMEP stations to be located near the borders with the Russian Federation and Ukraine and near the borders with Latvia and Lithuania, respectively. Ukraine plans to establish one additional EMEP station under its draft 2006–2010 State Environmental Monitoring Programme.

Global Atmosphere Watch programme

45. The goal of the World Meteorological Organization (WMO)/Global Atmosphere Watch (GAW) programme is to ensure long-term measurements to detect trends in global distributions of chemical constituents in air and the reasons for them. The programme coordinates global monitoring of aerosols, ozone, greenhouse gases, ultraviolet radiation, selected reactive gases and precipitation chemistry. Monitoring of chemical properties of aerosols is considered crucial in determining the role that aerosols play in climate, in documenting changes in regional air quality and in providing a scientific basis for policy decisions regarding control strategies. WMO/GAW have developed guidelines for aerosols measurements, proposing standards for compatible observations, quality assurance and common systems for calibration, data analysis and data archiving.[15] Another manual provides guidance on measurements of the chemical composition of precipitation, including standard operating procedures covering all on-site, laboratory, data management and quality assurance aspects of the measurement system.[16] Several GAW monitoring sites are also part of the EMEP network.

46. As part of the programme, there are some background monitoring stations in EECCA. In the Russian Federation, four stations are located in biosphere reserves in the European part and one station in the biosphere reserve in Siberia. Belarus, Kazakhstan and Uzbekistan have one station each, in areas remote from pollution caused by humans. The Institute on Global Climate and Ecology (Moscow) collects, processes and analyses observational data from all these stations

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[14] EMEP guidance material is available at www.nilu.no/projects/ccc/qa/index.htm.
[15] *Aerosol Measurement Procedures. Guidelines and Recommendations*. WMO/GAW No. 153, September 2003.
[16] *Manual for the GAW Precipitation Chemistry Programme. Guidelines, Data Quality Objectives and Standard Operating Procedures*. WMO/GAW No. 160, November 2004.

and publishes an annual review.[17] The network is considered insufficient and non-representative even for participating EECCA countries. Only Ukraine is planning to create one background monitoring station in the near future.

B. Relevant international guidelines

World Health Organization (WHO)

47. The second edition of *Air Quality Guidelines for Europe*, published in 2001, covers 32 pollutants that, due to their hazard to human health, should be monitored in ambient air.[18] Although health effects were the major consideration in establishing the *Guidelines,* evidence of the effects of pollutants on terrestrial vegetation was also considered, and guideline values were recommended for a few substances. When numerical air quality guideline values are given, these values are not standards in themselves. Before they are transformed into legally binding standards, the guideline values must be considered in the context of prevailing exposure levels, technical feasibility, source control measures, abatement strategies and social, economic and cultural conditions.[19]

International Organization for Standardization (ISO)

48. ISO is standardizing tools for air quality characterization of ambient air, in particular measurement methods for air pollutants[20] and for meteorological parameters, measurement planning, procedures for quality assurance/quality control and methods for the evaluation of results, including the determination of uncertainty. ISO also outlines the general principles to take into account when assessing the accuracy of measurement methods and results, and in applications, and to establish practical estimations of the various measures by experiment.[21]

III. AIR QUALITY MONITORING REQUIREMENTS IN THE EUROPEAN UNION AND THE UNITED STATES

A. European Union

49. The EU air quality management regime started in 1980 with Directive 80/779/EEC,[22] which established air quality limit values (AQLVs) and guide values for SO_2 and suspended particulates. In the meantime, a number of EU member States had already developed air quality

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[17] *Review of Background State of Environment of the Territory of EECCA Countries.*
[18] *Organic air pollutants:* acrylonitrile, benzene, butadiene, carbon disulfide, carbon monoxide, 1,2-dichloroethane, dichloromethane, formaldehyde, PAHs, polychlorinated dibenzodioxins and dibenzofurans, styrene tetrachloroethylene, toluene, trichloroethylene, vinyl chloride; *inorganic air pollutants:* arsenic, asbestos, cadmium, chromium, fluoride, hydrogen sulphide, lead, manganese, mercury, nickel, platinum, vanadium; *classical air pollutants:* nitrogen dioxide, ozone and other photochemical oxidants, particulate matter and sulfur dioxide.
[19] WHO (2002), *Air Quality Guidelines for Europe*, 2nd ed. WHO Regional Publications, European Series, No. 91.
[20] 21 ambient atmospheres standards/projects of TC 146/SC 3 and 11 general standards and/or guides of TC 146/SC 4 (www.iso.org).
[21] *1993 Guide to the Expression of Uncertainty of Measurements* and guidance for the accuracy of the measurement and for testing laboratories (ISO 5725-1-8:1994-1998 and ISO 17025:2005) (www.iso.org).
[22] Council Directive 80/779/EEC of 15 July 1980 on air quality standards for sulphur dioxide and particulates. *Official Journal of the European Communities (OJEC)* No. L 229.

regimes. Part of the challenge for the European Union has therefore been to harmonize not only air quality standards but also the national systems in place for assessing and monitoring air quality.

50. The 1996 Air Quality Framework Directive (AQFD)[23] and its Daughter Directives are aimed at establishing a harmonized structure for assessing and managing air quality throughout the European Union. Within this structure, EU member States are given considerable scope to determine what actions they will take to fulfil their commitment to meet the air quality standards within their territories.

51. AQFD stipulated 13 pollutants for which limit values (and, as appropriate, alert thresholds) were to be established. The actual setting of limit values and alert thresholds for specific pollutants is done via the Daughter Directives. The limit values represent long-term objectives equivalent to the WHO's new guideline values. Because the new values are considerably lower than the previous AQLVs and their attainment therefore requires major efforts to reduce pollution, temporary margins of tolerance are set for certain pollutants. These margins of tolerance are then reduced stepwise so as to provide interim targets until the AQLV is attained at the end of the determined period.

52. Besides establishing numerical AQLVs and alert thresholds for each of the identified pollutants, the Daughter Directives harmonize monitoring strategies, measuring methods, calibration and quality assessment methods to arrive at comparable measurements throughout the European Union and to provide effective public information.

53. The first Daughter Directive[24] set limit values for NOx for the protection of vegetation, and for the protection of health for SO_2, PM_{10}, NO_2 and Pb. The second Daughter Directive[25] established limit values for concentrations in ambient air of carbon monoxide and benzene. Target values for ozone, set in the third Daughter Directive,[26] are to be attained where possible by 2010, and in accordance with the Directive on national emission ceilings.[27] The remaining pollutants – poly-aromatic hydrocarbons, cadmium, arsenic, nickel and mercury – are covered by the fourth Daughter Directive.[28] This is due to be transposed into member States' law by 15 February 2007.

54. The 1996 AQFD requires EU member States to draw up a list of zones and agglomerations where the levels of one or more pollutants are higher than the limit value plus a

[23] Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management. *OJEC* No. L 296/55.
[24] Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air. *OJEC* No. L 163.
[25] Directive 2000/69/EC of the European Parliament and of the Council of 16 November 2000 relating to limit values for benzene and carbon monoxide in ambient air. *OJEC* No. L 313.
[26] Directive 2002/3/EC of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air. *OJEC* No. L 67.
[27] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, *OJEC* No. L 309/22.
[28] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, *OJEC* No. L 23/3.

margin of tolerance. Plans or programmes then have to be prepared and implemented for those zones in order to attain the AQLV within the time limit. Under the AQFD, member States have full competence for defining the geographical areas within their territories (in addition to all agglomerations with 250,000 or more residents which constitute a special type of zone covered *per se*) that will constitute zones for the purpose of air quality monitoring and assessment.

55. For certain pollutants, temporary margins of tolerance are set and then reduced stepwise so as to attain the limit value at the end of the determined period. The intensity of the monitoring that must be carried out under the AQFD depends on the degree to which a zone's air quality is in compliance with the AQLVs. Zones with a likelihood of an exceedence must be monitored more closely. The minimum number of stations is prescribed in a zone where levels are above the upper or lower assessment threshold and where monitoring is the sole source of information on the air pollution level. Often more stations are needed, depending on the complexity of the concentration distribution across the zone and the variety of source types. To comply with the directives, EU member States today monitor air quality at around 3,000 locations and routinely disseminate this information to the public and the European Commission.

56. The Framework Directive and the first Daughter Directive contain a series of provisions to ensure better and more comparable air quality data. These provisions include, in particular:

a) Criteria for network design and site selection;
b) Data quality objectives in terms of minimum accuracy, data capture and data coverage of the measurements;
c) Standardized reference measurement or equivalent methods;
d) The certification of equipment;
e) The designation of a national reference laboratory; and
f) The approval of laboratories.

B. United States

57. Measurements of pollutant concentrations are made at monitoring stations operated by state and local governments throughout the United States. The monitoring stations are generally located in larger urban areas. The Environment Protection Agency (EPA) and other federal agencies also operate some air quality monitoring sites on a temporary basis as a part of air pollution research studies. The national monitoring network conforms to uniform criteria for monitor siting, instrumentation and quality assurance.

58. The Clean Air Act (CAA) of 1963 and the Air Quality Act of 1967 established Air Quality Criteria, Air Quality Control Regions (AQCRs) and the process for State Implementation Plans. This framework was further developed and refined with the passage of the CAA Amendments in 1977 and 1990. Under the Clean Air Act, the EPA and states collect data on six air pollutants (CO, NO_2, SO_2, O_3, PM_{10} and $PM_{2.5}$, and Pb) to measure compliance with National Ambient Air Quality Standards (NAAQS).

59. "Primary" NAAQS are set to protect public health with an adequate margin of safety, and "secondary" NAAQS protect against adverse welfare effects (e.g. effects on vegetation, ecosystems, visibility, synthetic materials). After initially adopting NAAQS for each of the criteria air pollutants in the 1970s, the EPA has periodically reviewed and sometimes revised the

standards. The EPA recently revised the health-based standard for ozone and added a new standard for fine $PM_{2.5}$ based on new health studies.

60. In addition to specifying a maximum ambient concentration, NAAQS included descriptions of monitoring and statistical methods used to determine whether an area is in compliance with the standard. Primary standards were to be achieved by individually designated deadlines, and the EPA was authorized to force pertinent states to meet those deadlines. For secondary standards, however, neither deadlines nor enforcement authority was specified.

61. The CAA gave each state the primary responsibility for ensuring acceptable air quality within the entire geographic area comprising the state. Criteria air pollutants are monitored through the National Air Monitoring Stations/State or Local Air Monitoring Stations network. This network consists of more than 5,500 monitors operating at 3,000 sites across the country, mostly in urban areas.[29] Measurements are taken on both a daily and a continuous basis to assess peak concentrations and overall trends, and are reported in the EPA's Air Quality System (AQS) database.[30] In addition to other uses, the EPA analyses these air quality measurements to designate areas as either attainment or nonattainment for specific criteria air pollutants (i.e. determines if air quality levels in an area violate the NAAQS).

62. The Clean Air Act identifies 188 air toxins. The EPA does not set health-based standards for these pollutants. No formal monitoring network for air toxins currently exists, but several metropolitan areas do maintain monitoring programmes. Data from these areas provide the basis for an air toxins indicator. Selected air toxins are benzene, 1,3-butadiene, total suspended lead and perchloroethylene. There are approximately 310 ambient air toxin monitoring sites, primarily in cities and towns, the majority of which are federally funded and report data to AQS.

63. The EPA is also one of many sponsors of the National Atmospheric Deposition Program/National Trends Network (NADP/NTN), a nationwide network of over 200 precipitation monitoring stations. The purpose of the network is to collect data on the chemistry of precipitation for monitoring of geographical and temporal long-term trends.

64. The National Park Service operates approximately 30 stations in cooperation with the EPA. It is the nation's primary source for data on dry acidic deposition and rural ground-level ozone. The EPA is a major funding sponsor of the Interagency Monitoring of Protected Visual Environments (IMPROVE) programme.

65. The AQS stores data collected from over 10,000 monitors. The AQS also contains meteorological data, air toxins data, descriptive information about each monitoring station (including its geographic location and its operator) and data quality assurance/quality control information. The AQS database is updated nearly every day by states and local environmental agencies that operate the monitoring stations.

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[29] EPA (2003), Draft Report on the Environment Technical Document.
[30] See www.epa.gov/ttn/airs/airsaqs/index.htm.

66. The AirData website[31] provides annual summaries of ambient monitoring and emissions inventory data. There is also a cross-government website AIRNow[32] that provides the public with easy access to national air quality information. The site offers a daily forecast of conditions and associated health effects, known as the Air Quality Index (AQI), as well as real-time conditions for more than 300 cities across country. The EPA calculates the AQI for ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide and nitrogen dioxide. The standard index makes it easy to compare air quality in different parts of the country. The AQI has six categories: “good”, “moderate”, “unhealthy for sensitive groups”, “unhealthy”, “very unhealthy” and “hazardous”. Each category corresponds to a different level of health concern.[33]

67. This year the EPA has drafted legislation with a number of changes to the ambient air quality monitoring requirements to ensure that the national network of air monitors will meet the current and future data needs of EPA and other federal, state, local and tribal air quality management agencies. While much of this proposed rule outlines changes to the monitoring requirements for particulate matter, there are additional changes relating to all the other criteria pollutants included in this proposal.[34]

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[31] See www.epa.gov/air/data/.
[32] See airnow.gov.
[33] For details see airnow.gov/index.cfm?action=aqibroch.index.
[34] Environmental Protection Agency. 40 CFR Parts 53 and 58. Revisions to Ambient Air Monitoring Regulations. *Federal Register* 71 (10), January 17, 2006.

Annex I

AIR QUALITY MONITORING NETWORKS IN EASTERN EUROPE, CAUCASUS AND CENTRAL ASIA

COUNTRY AND YEAR	Fixed urban stations				Fixed precipitation monitoring sites	Fixed background stations	EMEP stations
	Total number	Number of cities covered	Of which automatic stations	Number of parameters measured			
Armenia 2005	13	6	None	Up to 11	None	None	None
Azerbaijan 2003	26	8	None	2–18	19	None	None
Belarus 2005	56[1]	16	1	6–32	16	1	1
Georgia 2006	15	6	None	2–8	10	None	None
Kazakhstan 2003	47	20	None	Up to 16	38	1	None
Kyrgyzstan 2005	14	5	None	3–7	None	None	None
Republic of Moldova 2005	17	5	None	Up to 8	9	None	1
Russian Federation 2005	755[2]	251[3]	57[4]	5–25 in most cities	110	5	4
Tajikistan 2003	4	2	None	5–8	-----	None	None
Turkmenistan 1998	18	7	None	4–11	-----	None	None
Ukraine 2005	169[5]	53	None	7–33	33	None	2
Uzbekistan 2005	59	33	None	3–22	-----	1	None

Note: ----- indicates that data are not available. *Source:* UNECE monitoring database and communications from EECCA countries.

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[1] Including stations of the sanitary and epidemiological service.
[2] Stations of both the State observational network (698, of which 629 stations operated by Roshydromet) and regional networks of subjects of the Russian Federation.
[3] 248 of which are covered by the State observation network operated by Roshydromet (in 229 cities) and cities' authorities.
[4] Operated by regional networks of subjects of the Russian Federation.
[5] Including 7 stations operated by city communal services.

Annex II

MAXIMUM ALLOWABLE CONCENTRATIONS/AIR QUALITY LIMITS IN EECCA COUNTRIES, THE EUROPEAN UNION, THE UNITED STATES, JAPAN AND WHO

	EECCA	EU	USA	JAPAN	WHO[1]
SO_2	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
20 minutes	500				500[2]
1-hour mean		350[3]		266	
3-hour mean			1300[6]		
24-hour mean	50[4]	125[5]	365[6]	90[7]	125
Annual mean		20[8]	80		50
NO_2	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
20 minutes	85[9]				
1-hour mean		200[10]			200
24-hour mean	40[11]			76 to 115[12]	
Annual mean		40	100		40
PM10		$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	
Hourly				200	
24-hour mean		50[13]	150	100[14]	
Annual mean		40	50		
PM2,5			$\mu g/m^3$		
24-hour mean			65		
Annual mean			15		
TSP	$\mu g/m^3$				
20 minutes	500				
24-hour mean	150				
CO	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
20 minutes	5000				

[1] WHO values are guidelines, not standards.
[2] 10-minute exposure.
[3] Can be exceeded up to 24 times per year.
[4] In Belarus – 200 $\mu g/m^3$.
[5] Can be exceeded up to 3 times per year.
[6] Not to be exceeded more than once per year.
[7] Daily average of 1-hour figure.
[8] Annual and winter mean for protection of ecosystems.
[9] The revised MAC is 250 $\mu g/m^3$ in Belarus and 200 $\mu g/m^3$ in the Russian Federation.
[10] Can be exceeded up to 18 times per year as of 1 January 2010.
[11] In Belarus – 100 $\mu g/m^3$.
[12] Daily average of 1-hour figure.
[13] Can be exceeded up to 35 times per year.
[14] Suspended particulate matter, daily average of 1-hour value.

	EECCA	EU	USA	JAPAN	WHO[1]
1-hour mean			40000		30000
8-hour mean		10000	10000	23200	10000
24-hour mean	3000			11600[5]	
OZONE	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
20 minutes	160				
1-hour mean			235		
8-hour mean		120[15]	157		120
24-hour mean	30				
BENZENE	µg/m^3	µg/m^3		µg/m^3	
20 minutes	1500[16]				
24-hour mean	100				
Annual		5[17]		3	
Photochemical oxidants				ppb	
Hourly mean				60	
Lead	µg/m^3	µg/m^3			µg/m^3
20 minutes	1				
24-hour mean	0.3				
3-month mean			1.5		
Annual		0.5			0.5
BENZO(A)PYRENE	µg/m^3	µg/m^3			
24-hour mean	0.001				
Annual		0.001			

Notes: µg/m^3 – micrograms per cubic metre of air; ppb – parts per billion; NO – nitrogen dioxide; NO – nitric oxide; SO_2 – sulphur dioxide; PM10 – particulate matter with a diameter less than 10 microns; PM2.5 – particulate matter with a diameter less than 2.5 microns; TSP – total suspended particle; CO – carbon oxide.
Conversion factors from ppb to µg/m^3: nitrogen dioxide 1 ppb = 1.91 µg/m^3; sulphur dioxide 1 ppb = 2.66 µg/m^3; ozone 1 ppb = 2.0 µg/m^3; carbon monoxide 1 ppb = 1.16 µg/m^3; benzene 1 ppb = 3.24 µg/m^3.

Source: UNECE Monitoring Database; *WHO Air Quality Guidelines*, 2nd ed. (2000); *A Comparison of EU Air Quality Pollution Policies and Legislation with Other Countries. Study 1. Review of the Implications for the Competitiveness of European Industry*. January 2004. AEA Technology Environment and Metroeconomica for the European Commission.

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[15] Target value; can be exceeded on 25 days/year averaged over three years.
[16] In Belarus and the Russian Federation – 300 µg/m3.
[17] As of 1 January 2010.