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Working Group on Effects

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RECENT RESULTS AND UPDATING OF SCIENTIFIC AND TECHNICAL KNOWLEDGE

HEALTH RISKS OF OZONE IN EUROPE

Report by the Task Force on Health [1]

INTRODUCTION

1. The eleventh meeting of the Task Force on the Health Aspects of Air Pollution was held on 17 and 18 April 2008 in Bonn, Germany. Thirty experts from 19 Parties to the Convention attended the meeting. A member of the secretariat also attended the meeting, as did staff from WHO. Mr. M. Krzyzanowski (WHO/ECEH) chaired the meeting. This report, presented here in accordance with item 3.8 (b) of the 2008 workplan for the implementation of the Convention

[1] The joint Task Force on the Health Aspects of Air Pollution of the World Health Organization (WHO)/European Centre for Environment and Health (ECEH) and the Convention's Executive Body.

(ECE/EB.AIR/91/Add.2) adopted by the Executive Body at its twenty-fifth session, comprises the results of the meeting and reports from Eastern Europe, the Caucasus and Central Asia (EECCA). The latter appears in the annex to the present document.

I. OZONE

2. The draft report prepared by the experts working for the Task Force and reviewed by the Task Force meeting summarizes the results of a multidisciplinary analysis aiming to assess the health impacts of ozone (O_3), especially the share contributed by remote sources. The analysis indicated that O_3 pollution affected the health of most of the European population, leading to a wide range of health problems. Currently implemented policies were not sufficient to reduce the impacts significantly in the next decade.

3. O_3 is a highly oxidative compound formed in the lower atmosphere from gases originating largely from anthropogenic sources, by photochemistry driven by solar radiation. Due to its highly reactive chemical properties, O_3 is harmful to vegetation, materials and human health. In the troposphere, O_3 is also an efficient greenhouse gas.

4. **Health hazards from short-term exposure.** Recent epidemiological studies have strengthened the evidence that daily exposure to O_3 increase mortality and respiratory morbidity. The studies have provided information on concentration-response relationships and effect modification. In short-term studies of pulmonary function, lung inflammation, lung permeability, respiratory symptoms, increased medication usage, morbidity and mortality, O_3 appeared to have effects independent of other air pollutants such as particulate matter (PM). This notion that O_3 might act independently was strengthened by controlled human studies and experimental animal studies showing the potential of O_3 per se to cause adverse health effects especially in vulnerable subjects. Studies of combined PM and O_3 controlled human studies corroborate this view.

5. **Health hazards from long-term exposure.** New epidemiological evidence and experimental animal studies on inflammatory responses, lung damage and persistent structural airway and lung tissue changes early in life, have indicated effects also of long-term O_3 exposure. While this evidence was still too limited to base firm conclusions on, in the future it might be possible to identify health effects from long-term exposure to O_3.

6. **Sources and emission trends.** The most important pollutants form tropospheric O_3 are nitrogen oxides (NOx) and volatile organic compounds (VOCs), as well as, to lesser but still significant extent, methane (CH_4) and carbon monoxide (CO). The pace of photochemical reactions forming O_3 in the atmosphere depends on the solar radiation and temperature. Inside

and close to urban areas, O_3 concentrations may be depressed because of reaction with NOx, but further downwind (in rural areas), both NOx and VOCs emissions promote O_3 formation.

7. The main sources of NOx are traffic, power generation and industrial sources. Emissions are located in the most densely populated areas of Europe, but with a focus in north-western Europe. VOCs emissions are more evenly distributed in Europe. Main sources of VOCs are traffic and solvents. In the European Union (EU) Member States, precursor emissions of O_3 are expected to decline further, even when assuming accelerated economic growth, decreasing to half the levels of the year 2000 by 2020. For these pollutants, the contributions from the traditionally dominating source sectors (energy production, industry, road transport) will significantly decrease. In the future, the relative role of other sectors will increase. These other sectors are currently subject to less strict legislation; they include shipping, diesel-powered heavy-duty and off-road vehicles for NOx, and use of solvents for VOCs. However, the lack of relevant, stringent legislation in many non-EU countries may result in further increases in precursor emissions of O_3 in these parts of the UNECE region.

8. **O_3 levels and trends.** Even though the emissions of O_3 precursors have decreased in large parts of Europe since the late 1980s, O_3 levels remain a health concern in Europe. The highest levels occur in Southern and Central Europe. Concentrations in Southern Europe are higher than in Northern Europe, and are higher in rural than in urban areas. A reduction in peak O_3 values during the 1990s could be seen in several regions in Europe, while there was no such trend in SOMO35 (sum of maximum daily 8-hour mean over 35 ppb (parts per billion)), a metric used for O_3 health impact assessment. O_3 levels are strongly influenced by inter-annual variations in weather conditions and trends in hemispheric background concentrations. Urban annual mean levels of O_3 are increasing.

9. Simulations of SOMO35 for 2010 indicated that the changes in emissions expected from 2000 to 2010 would lead to slight overall reductions in Central Europe. However, in some (urban) areas, the combination of reduced NOx titration and the increasing contribution of hemispheric background O_3 led to increasing exposures to ground-level O_3. Regional differences in O_3 levels across Europe were expected to decrease in the next decade. Exposures in continental Europe were projected to decrease by 20 to 30% in southern France, Germany, northern Italy and Switzerland, and to rise in the British Isles and Scandinavia.

10. Human exposure to O_3 during winter is reduced due to more time being spent indoors. Building structures and slow ventilation reduced O_3 penetration indoors also during summer.

11. **Health impact estimates.** It was estimated that approximately 21,000 premature deaths per year were associated with O_3 exceeding 70 $\mu g/m^3$ measured as a daily maximum 8-hour

mean in EU-25. The slight decline in ground-level O_3 was expected to result from current legislation and current policies addressing climate change. This CLE (current legislation) scenario, however, was estimated to reduce premature mortality by only approximately 600 cases per year between 2000 and 2020. Markedly larger reductions of approximately 40% could be achieved with implementation of the maximum technically feasible reductions emission scenario.

12. O_3 was additionally associated with 14,000 respiratory hospital admissions annually in EU-25. It affected the daily health of large populations in terms of minor restricted activity days, respiratory medication use (especially in children), and cough and lower respiratory symptoms. The estimated numbers affected are from 8 to 108 million person-days annually, depending on the morbidity outcome in question. Expected decreases in the morbidity outcomes, related to the implementation of current policies (CLE scenario) were more significant than for mortality, ranging from an approximate 8% reduction (respiratory medication use of adults) to 40% (cough and lower respiratory symptoms in children). However, hospital admissions associated with O_3 exposure were expected to increase due to the changes in population structure and larger populations of older people (>65 years) at risk. The current health impact estimates considered only acute health effects, and did not account for possible effects at short-term O_3 exposure levels below 70 $\mu g/m^3$ or from long-term exposures.

13. The premature mortality associated with O_3 in EU-25 was substantially lower than that of fine PM ($PM_{2.5}$). Nevertheless, O_3 is one of the most important air pollutants affecting health in Europe.

II. PARTICULATE MATTER

14. The Task Force discussed recent studies that have presented new evidence on health impacts of PM since the update of the WHO *Air Quality Guidelines* in 2005. These studies confirmed, and in general strengthened, earlier observations.

15. The Task Force took note of the studies on effects of long-term exposures:

(a) The “Women Health Initiative” in the United States of America in the period 1994–1998 suggested that the increase in risk per unit of $PM_{2.5}$ was markedly larger than previously observed;

(b) The “Extended Harvard 6 Cities Study” confirmed the linearity of the concentration-risk function across the whole range of $PM_{2.5}$ exposure. It indicated that the risk of deaths was linked to the $PM_{2.5}$ level in the preceding two to three years, but not to pollution

levels in the earlier period. This suggested that reducing pollution would lead to rapid health benefits;

(c) A Dutch cohort study in the period 1987–1996 showed long-term effect of traffic-related air pollution on mortality. This major European study tended to confirm previous evidence from North America. Effect estimates for $PM_{2.5}$ were quantitatively similar to earlier estimates, although not statistically significant. Mortality was also associated with proximity of the residence to major roads and traffic intensity.

16. The Task Force took note of the studies on impacts of PM on the development of cardiovascular diseases. They were indicated by the incidence of (non-fatal) cardiovascular events such as myocardial infarction, progress in coronary artery calcification, or ischemic and thrombotic effects in men with coronary heart disease.

17. The Task Force took note of the studies on the effects of PM on respiratory health, including:

(a) The effects of exposure to traffic-related air pollution increasing the incidence of infections, asthmatic and allergic symptoms of four-year old children observed in a birth cohort of approximately 4,000 children in the Netherlands;

(b) Short-term decrement in lung function following exposure to traffic-related air pollution on adults with asthma in London;

(c) Decrement in the rate of (aging-related) decline in lung function observed in adults reducing their exposure to PM in the period 1991–2002 observed in the Swiss “Sapaldia” study.

18. The Task Force took note on the improvements of risk assessment resulting from the recent studies, in particular:

(a) Confirmation of the linearity of association between concentration of $PM_{2.5}$ and mortality;

(b) Indication that the risk for mortality related to long-term $PM_{2.5}$ levels might be higher than those derived from earlier data of the American Cancer Society if exposure assessment were more precise;

(c) Evidence on effects on mortality of long-term exposure to traffic-related PM demonstrated by the recent European cohort study;

(d) Strengthening the evidence on impacts of air pollution on development of cardiovascular diseases, on development of respiratory disease in children as well as on beneficial effects of exposure reduction on lung function in adults.

III. BIOMASS COMBUSTION

19. The Task Force noted that at its tenth meeting it already had discussed the health hazards of PM due to biomass combustion. Those were addressed by the 2005 WHO *Air Quality Guidelines*. Biomass burning in fields or wildfires caused sometimes prolonged pollution episodes, which might affect large areas and substantial segments of the population.

20. The delegate of the Belarus presented a simple methodology estimating the emissions of harmful substances and greenhouse gases from forest fires.

21. The Task Force noted the current main concerns on PM and its impacts on health: (a) forest fires; (b) open burning; and (c) domestic wood (biomass) burning. According to estimates of the GAINS model, 20% of $PM_{2.5}$ was emitted from wood burning in Europe within the model domain of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants (EMEP). Any evaluation should include: (a) population exposure, in particular in areas having significant biomass burning and closeness of population exposed; and (b) indoor exposure, with links to outdoor exposure and inclusion of new standards and techniques for burning equipment.

22. The Task Force agreed to initiate a preliminary assessment of the current health impacts due to PM from biomass combustion. However, it noted that a full risk assessment was not yet possible. The preliminary evaluation would include:

(a) Gathering available information, including national and local studies;
(b) Qualitative evaluation of current situation;
(c) Identification of key questions and gaps in knowledge;
(d) Addressing the results from fuel substitution;
(e) Proposals for development of systematic tools for risk assessment;
(f) Coverage of a global view, e.g. developing countries;
(g) Addressing, in particular, agriculture, forestry and domestic heating;
(h) Linking to work in (i) integrated assessment modelling; (ii) the EECCA region; (iii) the Convention's outreach activities; and (iv) ongoing work under WHO.

IV. ACTIVITIES OF EECCA COUNTRIES ASSESSING THE HEALTH IMPACTS OF AIR POLLUTION

23. The Task Force noted that the structure of the Convention offered a working if complex framework to participate in air pollution prevention work. The EECCA countries were

encouraged to establish contact with the relevant bodies under the Convention that could support work on health impacts.

24. The Task Force welcomed the good participation from EECCA and took note of the information presented by the experts from that region (see annex).

V. EFFECTS GUIDELINES

25. The Task Force considered the need to develop the guidelines for reporting on the monitoring and modelling of effects of air pollution on health. While it was understood that the direct measurement of health impacts of air pollution was not possible, epidemiological and statistical methods allowed for estimation of the risks in a population. Such estimates could then be used to assess the magnitude of the impacts. Monitoring would need to consider concentration-response functions (which, potentially, may vary between various populations and may change with time), the background frequency of the health condition augmented by the pollution and exposure levels characteristic for a given population.

26. The APHEIS programme (Air Pollution and Health: A European Information System) was created on the basis of the project implemented in 26 European cities in the period 1999–2004. Its experiences were presented and discussed as a possible background for the future health effects monitoring approach. Experiences of other projects such as CITEAIR (Common Information to European Air) could also provide an important input to creating guidelines. Such monitoring would need to rely on health and air quality information specific to selected populations. It would imply creation and maintenance of relevant institutional capacities for collecting and analysing the data according to the agreed methodology. The Task Force agreed to include the development of the guidelines in its workplan. The draft guidelines would be discussed at the twelfth Task Force meeting.

VI. PARTICIPATION

27. The Task Force noted that the substantial contributions of the experts supporting its work as well as the improving participation in its meetings of representatives from EECCA and South-East European countries. It also stressed the need for the consistent participation of representatives of all Parties in its work, which would assure continuous support for the Convention.

VII. 2008 AND 2009 WORKPLANS

28. The Chair presented the main results of the Convention's 2008 workplan items for the Task Force on Health.

29. **Annual progress report on health impacts of PM.** The Task Force took note of the results of the studies summarized and discussed at the meeting. These results strengthened the previous evidence on the health damage caused by PM. The Task Force confirmed the need for further action to effectively reduce both populations' exposure to PM and PM-related effects on health.

30. **Interim report on health impacts of O_3.** The Task Force took note of the draft report, Health risks of ozone from long-range transboundary air pollution. It concluded that O_3 was one of the most important air pollutants associated with health in Europe. Available data indicated that currently implemented policies were not sufficient to reduce impacts of O_3 significantly in the next decade.

31. **Final report on health risks of heavy metals.** The Task Force noted that the report, Health risks of heavy metals from long-range transboundary air pollution, had been published at the end of 2007.

32. While discussing its workplan for 2009, the Task Force was requested to consider a possibility of evaluating the health relevance of air pollution alert systems. The objectives of such systems ranged from information on current health risks of air pollution to actions involving activities of people and/or pollution sources. Experiences of countries in using such systems were not widely disseminated. The Task Force agreed that the review of such measures and of their health effectiveness would be beneficial to the Parties. Collaboration with the Working Group on Strategies and Review was recommended in the preparation of the review.

33. The Task Force agreed on its draft 2009 workplan, which would comprise:

(a) An annual progress report on the health impacts of PM;
(b) A final report on the health impacts of O_3;
(c) A preliminary report on health impacts due to biomass combustion;
(d) A review report on the health relevance of pollution alert systems;
(e) Development of guidelines for reporting on monitoring and modelling of health effects of air pollution;
(f) The twelfth meeting of the Task Force, tentatively scheduled to be held on 28 and 29 April 2009 in Bonn, Germany.

Annex

Reports on national air pollution activities submitted by the experts from Eastern Europe, Caucasus and Central Asia and South-Eastern Europe

I. ARMENIA

1. The modernization and expansion of existing air monitoring network as well as establishment of new networks is planned for the period 2009–2011. Currently, no monitoring is conducted for coarse PM (PM_{10}) or $PM_{2.5}$. Other pollutants are monitored in six cities. In Yerevan, monthly means for dust (total suspended particles, or TSP) varied from 120 to 400 µg/m^3 in 2007. Nitrogen dioxide (NO_2) monthly means exceeded 80 µg/m^3 for most of 2007. In the industrial town of Alaverdi, monthly mean sulphur dioxide (SO_2) levels exceeded 500 µg/m^3 in 2007. High air pollution was observed also in other cities. Development of legislative acts, guidelines and methodologies for health impact and risk assessment, as well as an improvement of air quality monitoring network, were priority issues still to be solved in Armenia. The update of air quality-related legislation, conducted in 2007, addressed abatement of dust from construction activities as well as emission of O_3-depleting gases. An interagency committee had been organized for coordination and development of state environmental monitoring.

II. AZERBAIJAN

2. The monitoring of air quality is operated by the Ministry of Ecology and Natural Resources in eight industrial cities (27 stations). It covers 18 pollutants including TSP, soot, mercury, CO, sulphur oxides (SOx), NOx and VOCs. State sanitary surveillance services of the Ministry of Health found that maximum permissible level was breached in 27% of all collected samples. PM_{10}, $PM_{2.5}$ and O_3 have not been monitored.

3. The main sources of pollution in Baku are industry and transport. Poor management of the city traffic, low-quality fuel and large number of old vehicles have had negative impacts on air quality and human health in Baku. A direct consequence of air pollution in the city was the increasing number of allergic and respiratory diseases. The Ministry of Health plans to prepare, in 2009–2010, a national assessment of children's environmental health and chemical safety.

4. Azerbaijan has advanced chemical and petroleum-refining industries. Chemical safety is a constant focus of attention for the general public and experts. A major concern is air pollution in industrial city of Sumgait. Cancer rates in Sumgait are considerably higher than national

averages and rates, and the mortality rate from cancer in Sumgait exceeds the national average by 8%.

5. Current regulations on environmental protection and chemical safety are included in various legal acts. However, all these laws are rather general, and the norms in many respects require revision. The air pollutant inventory and maximum permissible levels of air pollutants are established by the Ministry of Health.

III. BELARUS

6. Air quality monitoring is carried out in 18 towns at the 62 monitoring locations and covers 81.3% of the urban population. Two automatic monitoring stations for continuous measurement of nine priority air pollutants (including PM_{10} and ground-level O_3) were installed in Minsk in 2007. The background air quality monitoring was upgraded with technical improvements in the Berezinski Reserve station, where analysers of PM_{10}, SO_2, NOx, CO and O_3 were installed. In 2007, monthly average of PM_{10} concentrations was in the range of 20–30 $\mu g/m^3$ in all four cities with PM_{10} monitoring. The daily mean PM_{10} concentrations exceeded 50 $\mu g/m^3$ in 12–18 days only; this frequency was half of the 2006 level.

7. Emissions from vehicles, which constitute 81% of the total amount of air pollution, have a negative impact on the air quality in towns. The pollution caused by vehicle use covers 15.4% of the territory.

8. A special programme to reduce the harmful impacts of the vehicles on the environment and human health was adopted for the period 2007–2010. The programme seeks to improve the statutory legal base, the technical and economical characteristics of the vehicles and vehicle exploitation methods; to renew the vehicle fleet; and to introduce efficient and stable transport systems.

9. A methodology for assessing the consequences of vehicle emissions impacts on the environment and human health is in the process of adoption. A cost-based assessment of the influence of the main pollutants and greenhouse gases has been defined within this methodology.

10. A technical statutory act regulating the introduction of automatic control systems for air pollutants and greenhouse gases from stationary sources of large industrial plants has been accepted.

IV. CROATIA

11. Air quality has been monitored in Croatia since 1964. State and local monitoring networks are being updated, extended and improved to meet international commitments. The monitoring networks are based on a total of 140 stations. The list of monitored pollutants includes O_3, SO_2, NO_2, NOx, PM_{10}, $PM_{2.5}$, lead, CO and benzene.

12. The current national air quality monitoring system is based in five cities at eight sites. The monitoring covers SO_2, NO_2, CO, PM_{10}, O_3, BTX (benzene, toluene, etilbenzene, o-p-m xylen), ultraviolet B radiation (UV-B) and meteorological parameters. A PHARE project, "System for monitoring and management of air quality", funded by the European Commission, is preparing an upgrade of the State network for continuous monitoring of air quality. It will cover populated and protected areas and also transboundary air pollution. Future monitoring activities in the urban and industrial areas will be conducted, with the emphasis on health aspects and health conditions of the population concerned.

13. An air protection act and an implementing regulation on limit values of pollutants in ambient air (22 pollutants) were adopted in 2004. Regulation on critical levels of pollutants in ambient air was adopted in 2005.

V. GEORGIA

14. In conformity with the law on the protection of atmospheric air, only the emissions of air pollutants from stationary sources are included in the emission inventories, although mobile sources and agriculture contribute to air pollution significantly. Fuel consumption and consequent atmospheric emission of dangerous substances have grown in recent years. The main pollutants are CO, CH_4, VOCs, solid particles (inorganic dust), ammonia and nitric oxide (NO).

15. The Centre for Monitoring and Forecasting of the Ministry of the Environment assesses air pollution in six cities: Tbilisi, Rustavi, Kutaisi, Zestafoni, Batumi and Akhaltsikhe. It measures eight pollutants: TSP, SO_2, NO_2, hydrogen sulphide, carbon dioxide, NO, soluble sulphate and magnesium dioxide. In 2006 and 2007, high or extreme levels of pollution were not been reported.

16. The incidence and prevalence rates of respiratory system diseases are high, especially in children, accounting for 60.8% of all registered diseases in this age group. The incidence of respiratory diseases in children doubled in the period 1998–2005.

17. Several laws regulate the protection of atmospheric air in Georgia. Air quality standards considering human health and safety are established by the Ministry of Labor, Health and Social Affairs.

VI. KYRGYZSTAN

18. In 2006, atmospheric air pollution total emissions from all stationary sources increased in Kyrgyzstan by 4.6% as compared with 2005 and amounted to 36,100 tons. The major part of emissions was in Bishkek (45.4%) and the Chui region (34.1%). Monitoring of atmospheric dust levels has not been conducted since 2000, and $PM_{2.5}$ and PM_{10} measurements have not been conducted at all. In Bishkek, NO_2 and NOx pollution increased 2.7 to 3.7 times in 2006: The most polluted area remains the central part of the city, where maximum allowable concentrations (MACs) were exceeded for all harmful substances. In other cities (Kara-Balta, Tokmok and Cholpon-Ata), observed air pollution levels were lower than in Bishkek.

19. The national health care reform programme “Manas taalimi” for the period 2006–2010 was adopted in 2006. A national children’s environment and health action plan was developed in 2007 in draft form.

20. Respiratory diseases are the most common cause of morbidity of adults and adolescents. These diseases are the second leading cause of death after cardiovascular diseases (10.4% and 47.3%, respectively), followed by injuries and accidents (10%).

21. The main national laws on environmental protection, comprising environment, air and ecological examination, were established in 1999. A law on sanitary and epidemiologic well-being of the population was adopted in 2001 and is being revised. From 1995 to 2008, the Kyrgyz Republic ratified 12 international nature conservation conventions and three protocols to them, including the Convention on Long-range Transboundary Air Pollution in 2000.

VII. MOLDOVA

22. The first results of background monitoring in Rezina showed that the annual mean PM_{10} was in the range 17–30 $\mu g/m^3$. There are plans to harmonize national air quality legislation and monitoring with WHO recommendations and EU regulations.

VIII. RUSSIAN FEDERATION

23. Air quality was monitored in more than 460 locations, with three to four daily measurements. Altogether, 96 various substances were measured, with NOx, SOx, TSP, CO, benzo[a]pyrene (BaP), phenol, formaldehyde, ammonia and lead being the most often tested. For most pollutants, the percentage of samples indicating exceedance of MACs was reduced in the recent decade. In 2006, of all air samples, 2.4% exceeded MACs; this was a reduction of 8.7% from 1996.

IX. THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA

24. Several air pollutants levels have been monitored in Skopje and Vles since the early 1990s. SO_2 concentrations were 18 and 26 µg/m^3, respectively, in 2006. In both cities the levels were markedly lower in 2006 than in the 1990s. The black smoke levels were 26 and 18 µg/m^3, respectively. The decrease was less evident than for SO_2. Since 2004, data on PM_{10} have been available for Skopje and Vles, with annual average levels in the ranges of 75–130 and 55–70 µg/m^3, respectively. Traffic was indicated as an important PM source.

25. Further improvement of the ambient air quality is necessary to reduce the incidence rate of the respiratory diseases, which are on the most common cause of morbidity in the country.

26. The EU air quality directives are currently being transposed into the national legislation, with the objective of completing this activity by the end of 2008. Rulebooks on monitoring and reporting, as well as on plans and programmes, have been drafted by the Ministry of the Environment in consultation with other relevant ministries.

X. UKRAINE

27. Monitoring of air pollution is conducted in 55 cities of Ukraine at 137 stationary stations. More than 2,500 hygienic standards of harmful substances in atmospheric air have been adopted.

28. In 2007, 297,000 air samples were analysed. The total percentage of air samples exceeding hygienic standards was 8.4% in cities and 1.4% in rural districts. In 14.6% of cases, exceedance of hygienic standards was established per summary content of TSP.

29. The highest levels of contamination are found in the industrial cities in the south-eastern part of the country. These are caused by the atmospheric emissions of by-products from coking, metallurgy and chemical industries. The main air pollutants are NOx (exceedance of standards in 9.5% of samples) and SOx (exceedance in 5% of samples). In Kiev and other large cities, transport is the main air pollution source.

30. Harmonization of the normative and analytical bases for PM and O_3 are the main problems of air pollution monitoring requiring immediate attention.
