FINNISH METEOROLOGICAL INSTITUTE

Committee for Nature Use,
Environmental Protection
and Ecological Safety,
St. Petersburg

AIR QUALITY MONITORING COOPERATION

EVALUATION REPORT

Photo: City of St. Petersburg

Enhancing Air Quality Monitoring in St. Petersburg through regional cooperation

Committee for Nature Use, Environmental Protection and Ecological Safety, St. Petersburg City Administration
Finnish Meteorological Institute 2013

AIR QUALITY MONITORING COOPERATION EVALUATION REPORT

Enhancing Air Quality Monitoring in St. Petersburg through regional cooperation

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ABBREVIATIONS

AMS	Air Monitoring System
AQM	Air Quality Monitoring
BIF	The Baltic Institute of Finland
Committee	Committee for Nature Use, Environmental Protection and Ecological Safety of the city of St. Petersburg
DI	Designated Institute
FAPPS	Finnish Air Pollution Prevention Society
FMI	Finnish Meteorological Institute
HSY	Helsinki Region Environmental Services Authority
MIKES	The Centre for Metrology and Accreditation (Finland)
MINERAL	The State Geological Unitary Enterprise “Specialized company “Mineral”
MoE	Ministry of the Environment
MPC	Maximum Permissible Concentrations
NMI	National Metrology Institute
NRL	National Reference Laboratory
PAH	Polyaromatic hydrocarbons
QA/QC	Quality Assurance Quality control
SOP	Standard Operation Procedure
SPb	St. Petersburg
VNIIM	D.I. Mendeleev All-Russian Institute for Metrology
VOC	Volatile Organic Compound

1 EXECUTIVE SUMMARY

Project Background

Air Quality Monitoring Cooperation project was started in 2004 in the framework of the city Twinning Programme established between the Finnish Ministry of Environment and the Committee for Nature Use, Environmental Protection and Ecological Safety of the City of St. Petersburg. With the long-term bilateral air quality monitoring cooperation between Finland and the City of St. Petersburg, Russia has been aiming to improve and develop methods for air quality monitoring and to enhance the presentation, dissemination and exchange of air quality information.

Main objectives of the project were to utilize experiences and lessons learnt by the project partners in Finland and St. Petersburg to promote joint cross-border efforts in improving air quality and develop and harmonize the air quality monitoring system in St. Petersburg with the EU standards, The project was funded by the Finnish Ministry of Environment and the Committee for Nature Use, Environmental Protection and Ecological Safety, City of St. Petersburg.

Cooperation Phases

The first phase of the project was launched in 2004 in the framework of “City Twinning program” between the Cities of Tampere, Finland and St. Petersburg, Russia. The project has included five phases during the years 2004–2013. Finnish Meteorological Institute and the City of St. Petersburg were the main implementers of the project activities providing the air quality expertise. The Baltic Institute of Finland was coordinating the project during four project phases from 2004 to 2012.

The first implementation phase in 2004–2006 was designed to enhance reduction and prevention of pollution in Baltic Sea area with special emphasis on improvement of the air quality in the St. Petersburg region. This meant practical level collaboration between cities and experts to identify needs and opportunities in developing the air quality monitoring system and information distribution as well as to create basis for continuous exchange of information and experiences.

The second project phase in 2006–2007 concentrated on practical level cooperation with the quality of the monitoring data as one of the main issues. Comparison measurement campaigns were performed based on the recommendations of the first cooperation phase. Campaigns were aiming to examine the comparability of the measurements and modeling results between Finnish Meteorological Institute and the City of St. Petersburg. Comparison dispersion modeling exercises were also carried out followed by recommendations for methodology improvements. The comparison exercises are used to demonstrate the comparability of the measurements. They also give valuable information about the accuracy and quality of the measurements.

The third project phase in 2008–2010 had three major achievements; establishment of on-line information exchange between the selected background air quality monitoring stations in Finland and St. Petersburg area; strengthening the Quality

Assurance and Quality Control activities; and initiating the development of ship emission inventory system for the city of St. Petersburg.

The fourth project phase in 2010–2012 was dedicated to strengthening, further development and improvements in all fields of activities launched in previous phases. In addition, the new methodology for ship emission inventory was implemented and the impact of ship emissions to the air quality in St. Petersburg was assessed. During this project phase the cooperation was expanded by the EU funded project BSR INNOSHIP including 21 partner organizations from 10 different countries around Baltic Sea Region.

Key Achievements

In the framework of air quality monitoring cooperation between Finland and St. Petersburg, enhance joint cross-border efforts in improving air quality and developing air quality monitoring system in St. Petersburg were made through the joint expert-level concrete activities throughout the different project phases.

The main results and achievements of the project are:

- Enhanced air quality cooperation and knowledge of air quality assessment methodologies and legislative instruments between St. Petersburg area and Finland;
- Improved skills of experts in air quality assessments;
- Development, improvement and harmonization of the Air quality Monitoring System in St. Petersburg according the EU standards;
- Improvement of the air quality assessments by dispersion modeling and the use of modeling data to support the decision making,
- Development of new methodologies and legal documents for air quality measurements, emission inventories and dispersion modeling activities
- Development of new ship emission impact inventory methodology
- Assessment on the impact of ship emissions to the air quality of the cities;
- Online data exchange between the background air quality stations in Finland and St. Petersburg area;
- Wide dissemination of the project results nationally and internationally;
- Initiation of further development activities; for example the BSR INNOSHIP project funded by EU with 21 partners from 10 countries around Baltic Sea area.

The air quality monitoring network of the city of St. Petersburg was expanded and improved significantly during the project. In 2004 the air quality monitoring network in St. Petersburg included 12 automatic monitoring stations and in 2013 there were altogether 21 automatic stations in operation. The QA/QC procedures meet the national standards and the standards developed by the European Committee for Standardization. The use of the described QA/QC measures makes it possible to obtain reliable data connected with monitoring of the atmospheric air pollution, comparable with the data of the European monitoring systems.

Sustainability

Sustainability of project results has a solid base. The project focus was to enhance practical operational processes and methods on both sides. Number of legal documents (operational processes to be in accordance with the legal documents) were developed during the project and implemented in practice. Methodological documents improved and created during the project have passed the expert evaluation and have become official practices. The results and experiences of the project have been widely disseminated in Russia and Finland which ensures the sustainability of the project results for wider use besides the project partners. Active dissemination of project results increases also the environmental awareness, which was one the objectives of the project. The City of St. Petersburg has done considerable investments to develop the air quality monitoring network of the City of St. Petersburg during the project. Economical and human resources have been well secured for the air quality management. The City of St. Petersburg has also systematic plans for the future development of the air quality monitoring network and the funding decisions for the development are also made. Thus, the sustainability of the project results is expected to be secured.

One of the achievements of the project is the online data exchange between six air quality background stations in St. Petersburg area and Finland. At this stage the continuation of data exchange is still open, but there is a common will to continue or extend the data exchange. However, the development of the online information exchange will require resources.

Lessons Learnt

During the cooperation there has been many valuable lessons learnt by both partners. In general level the lessons learnt can be summarized as following:

- Twinning partnership and very practical approach is an excellent tool to achieve long term sustainable results;
- Experiences from the joint activities have been important for the both project partners;
- During the project the competence of the experts and institutions working in the project has increased significantly;
- New knowledge about the legislative differences and methodological differences between Finland and Russia has been gained. Nevertheless the information and methodologies are comparable;
- Differences in legislation and regulations do not impede mutually beneficial cooperation;

- Information exchange between the project partners in general has been very useful.
- The bilateral cooperation has a good potential to communicate information and involve other parties in cooperation;
- Co-operation has improved the knowledge of the air quality in St. Petersburg, the assessment methods and the representativeness and quality of the air quality data;
- Project has been good basis for other international projects.

Future Challenges and the Cooperation

The cooperation within the framework of "Development of air quality monitoring system in St. Petersburg" project has been effective in strengthening the cooperation and air quality expertise in Finland and St. Petersburg area. The concrete results of the project are disseminated widely to other Russian regions where the air quality monitoring systems can be developed in accordance to the results of the project

Based on the good and beneficial experiences of air quality cooperation, it is recommended to continue cooperation in the following directions:

- Extending the online air quality information exchange to cover more areas and countries;

- Climate Change and Greenhouse Gases. Climate change is causing increasing frequency and intensity of extreme climatic events, leading to increase in economic losses. Exchange of experience in adapting to the conditions of urban areas to climate change is a priority for the sustainable development of the St. Petersburg area;

- Reducing the negative impact of ship emissions in urban areas. Construction of a new passenger port in St. Petersburg, together with measures to simplify the visa regime for passengers arriving on cruise ships, has encouraged the rapid growth in the number of passenger ships coming into the city.

2 INTRODUCTION

This report describes the background, key elements and achievements of the air quality monitoring (AQM) cooperation between Finland and the city of St. Petersburg covering the period from 2004 to 2012. The project was initiated through the City Twinning activities between the City of St. Petersburg and Tampere and it has been funded by the Ministry of Environment and the City of St. Petersburg. AQM project has been jointly implemented by the Environment and the Committee for Nature Use, Environmental Protection and Ecological Safety of the city of St. Petersburg, Finnish Meteorological Institute and Baltic Institute of Finland. The main experiences, results and achievements gained within different project phases as well as the practical impact they have had in both countries have been highlighted and evaluated in this report. These findings are used as basis of recommendations for further cooperation activities.

The long-term AQM cooperation has included many project phases and various activities dealing with the improvement of air quality assessment methodologies and information exchange. The main topics of the cooperation have been the development of instrumental monitoring, dispersion modeling and online data exchange. The project activities have been implemented through practical level cooperation which has offered a great opportunity for the experts working in the project to develop their skills and competences in air quality assessments.

Despite of the differences in the air quality legislation in Finland and Russia, the benefits of the project are clear. Among the improved skills of the experts the project has generated new air quality information and improvements of existing methodologies. New methodologies and new legal documents have been generated and new bilateral activities have been initiated during the project i.e. the online data exchange between the project partners including background air quality stations in Finland and St. Petersburg area.

The project results have been disseminated widely in both countries and also internationally. For example, the Committee has organized seminars where over 120 participants from 57 cities and Russian Federation subjects have participated.

Beside the dissemination of project results, a new networks and connections between experts and organisations in Finland and St. Petersburg have been created

3 BACKGROUND

3.1 How the Project got started?

The project was founded within the framework of “City Twinning Program” established between the Ministry of Environment and the Committee for Nature Use, Environmental Protection and Ecological Safety of the city of St. Petersburg in 2004.

In the beginning, the project aimed to promote the co-operation and information exchange between the air quality experts of Finnish cities and city of St. Petersburg. First step of cooperation was a comprehensive study of the air quality management system of the city of St. Petersburg that was jointly prepared by experts from city of St. Petersburg and Finland. The study has sought to identify the current system, it’s possible shortcomings and development needs, as well as opportunities for cooperation with Finnish and other European partners. The study was the first cooperation action, which started the long term cooperation between the project partners. The recommendations for future cooperation needs and objectives were formulated in the study and later on developed between the project partners.

3.2 Air Quality Standards

In Finland

In Finland, the air quality standards; limit values and guidelines are based on the European Union’s Air Quality directives that define the health based limit values for the most common pollutants. The main purpose of the EU air quality legislation is to protect human health and the nature from the negative effect of pollutants in the air. The idea is to maintain the good air quality in the clean areas and also to improve the air quality in urban and industrialized areas. In addition to European Union limit values there are also national guideline values. Limit values are binding and they cannot be exceeded without consequences. All the exceedances of the limit values are reported to European Union and actions to improve the air quality are required in case of exceedances. National guideline values are used to support the city and land use planning. In Finland, there are altogether 14 regulated compounds (SO_2, NO_2, NOx, PM_{10}, $PM_{2,5}$, Pb, C_6H_6, Co, O_3, As, Cd, Ni, B[a]P, TSP, TRS,). The limit values and national guideline values are presented in Tables 1.1–1.3

Table 1.1 EU air quality legislation under the 1997 Air Quality Framework Directive (96/62/EC)

Council Directive 96/62/EC on ambient air quality assessment and management	Air Quality Framework Directive, replaced by the CAFÉ directive
Council Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air	First Daughter Directive, replaced by the CAFÉ directive
Directive 2000/69/EC of the European Parliament and of the Council relating to limit values for benzene and carbon monoxide in ambient air	Second Daughter Directive, replaced by the CAFÉ directive
Directive 2002/3/EC of the European Parliament and of the Council relating to ozone in ambient air	Third Daughter Directive, replaced by the CAFÉ directive
Directive 2004/107/EC of the European Parliament and of the Council relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air	Fourth Daughter Directive
Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States	EoI Decision, replaced by the CAFÉ directive
Commission Decision 2004/461/EC laying down a questionnaire for annual reporting on ambient air quality assessment under Council Directives 96/62/EC and 1999/30/EC and under Directives 2000/69/EC and 2002/3/EC of the European Parliament and of the Council	
Commission Decision 2004/224/EC laying down the obligation of Member States to submit within two years so-called Plans and Programmes for those air quality zones where certain assessment thresholds set in the Directives are exceeded.	

Table 1.2. EU air quality standards

Pollutant	Protecting	Period of analysis	Value	Status
Nitrogen dioxide (NO_2)	Human health	Annual mean	40 μg m^{-3}	Limit value; valid from 2010
	Human health	Hourly mean; exceedances may occur for a maximum of 18 hours per year	200 μg m^{-3}	Limit value; valid from 2010
Nitrogen oxides (NO_X)	Vegetation	Annual mean	30 μg m^{-3}	Critical level
Particulate matter (PM_{10})	Human health	Annual mean	40 μg m^{-3}	Limit value; valid since 2005
	Human health	Daily mean; exceedances may occur for a maximum of 35 days per year	50 μg m^{-3}	Limit value; valid since 2005
Particulate matter ($PM_{2.5}$)	Human health	Annual mean	25 μg m^{-3}	Target value, to be reached in 2010; limit value, enters into force in 2015
	Human health	Annual mean	20 μg m^{-3}	Indicative limit value; valid from 2020, to be reviewed by the Commission in 2013
Ozone (O_3)	Human health	Maximum daily 8 hour mean; exceedances may occur for a maximum of 25 days per calendar year, averaged over three years	120 μg m^{-3}	Target value; to be reached in 2010
	Vegetation	AOT40, accumulated over May to July, averaged over five years	18 000 (μg m^{-3})·h	Target value; to be reached in 2010
Sulphur dioxide (SO_2)	Human health	Hourly mean; exceedances may occur for a maximum of 24 hours per calendar year	350 μg m^{-3}	Limit value; valid since 2005
	Human health	Daily mean; exceedances may occur for a maximum of 3 days per calendar year	125 μg m^{-3}	Limit value; valid since 2005
	Vegetation	Annual / Winter (1 October to 31 March) mean	20 μg m^{-3}	Critical level
Benzene	Human health	Annual mean	5 μg m^{-3}	Limit value; valid from 2010
Carbon monoxide (CO)	Human health	Maximum daily 8 hour mean	10 mg m^{-3}	Limit value; valid since 2005
Lead (Pb)	Human health	Annual mean	0.5 μg m^{-3}	Limit value; valid since 2005
Arsenic (As)	Human health	Annual mean; for the total content in the PM_{10} fraction	6 ng m^{-3}	Target value; to be reached in 2013
Cadmium (Cd)	Human health	Annual mean; for the total content in the PM_{10} fraction	5 ng m^{-3}	Target value; to be reached in 2013
Nickel (Ni)	Human health	Annual mean; for the total content in the PM_{10} fraction	20 ng m^{-3}	Target value; to be reached in 2013
Benzo(a)pyrene (as a marker for the carcinogenic risk of PAHs)	Human health	Annual mean; for the total content in the PM_{10} fraction	1 ng m^{-3}	Target value; to be reached in 2013

Table1. 3 Finnish national air quality guideline values.

Pollutant	Period of analysis	Guideline value (20°C, 1 atm)	Statistical definition
Carbon monoxide (CO)	Hourly mean	20 mg m^{-3}	Hourly mean
	8 hour mean	8 mg m^{-3}	Moving average
Nitrogen dioxide (NO_2)	Hourly mean	150 μg m^{-3}	99. percentile monthly
	Daily mean	70 μg m^{-3}	Second largest daily mean monthly
Sulphur dioxide (SO_2)	Hourly mean	250 μg m^{-3}	99. percentile monthly
	Daily mean	80 μg m^{-3}	Second largest daily mean monthly
Total suspended particles (TSP)	Daily mean	120 μg m^{-3}	98. percentile annually
	Annual mean	50 μg m^{-3}	Annual mean
Particulate matter (PM_{10})	Daily mean	70 μg m^{-3}	Second largest daily mean monthly
Total reduced sulphur (TRS)	Daily mean	10 μg m^{-3}	Second largest daily mean monthly (expressed as sulphur)

European Union's air quality policy is continuously revised and the legislation is further developed. In Finland the national legislation is focusing on taking the air quality issues into consideration already in the planning phase of the projects in order to prevent the degradation of the air quality.

In St. Petersburg/Russia

The priority of the Russian air quality legislation is the protection of human life and health, the present and future generations. The aim is to ensure favorable environmental conditions for living, labour and leisure and to prevent the irreversible environmental consequences of the air pollution. The state regulation for the pollutant emissions to the air and for the negative physical impact on the air is obligatory. The principles of the air quality legislation include the transparency, completeness and reliability of the information on the state of the ambient air and on the air pollution. The legislation aims to scientific, systematic and integrated approach to the air protection and to the environmental protection in general.

The maximum permissible concentrations are established by the sanitary and epidemiologic regulations and standards "Hygienic requirements to the air quality in residential areas SanPiN 2.1.6.1032-01". The bases of the regulation for the air quality in residential areas are the hygienic standards – maximum permissible concentrations (MPC) of chemical and biological pollutants. MPC are established to prevent odours, irritant action and reflex reactions and acute impact of the air pollution on human health during short-term raise of concentrations, as well as prevention of negative impact on the human health resulting from long-term exposure to the air pollutants (*EU-Russia Program of Cooperation, 2008*).

The Law on the Air Protection was adopted on May 4, 1999, and since that time it underwent amendments by relevant laws of 22.08.2004, 09.05.2005, 31.12.2005, 23.07.2008, 30.12.2008, 30.12.2008, 27.12.2009, 18.07.2011, 19.07.2011, 21.11.2011, 25.06.2012.

According to the Federal Law on the Air Protection, the entities of the Russian Federation have the right to establish regional air quality standards, which should not be less strict than the Federal standards. No regional standards have been set in St. Petersburg at the moment. Therefore, the Federal standards, established by SanPiN 2.1.6.1032-01, are applied.

3.3 Key Problems in Air Quality

In Finland

The air quality in Finland is generally good compared to the average in Central and Southern Europe. The local individual emissions are relatively low, which is result of the successful emission reduction programs. Finland's location far from large emission sources such as the southern major cities and industrial areas is one of the reasons for the good air quality.

In Finland, however, some air quality problems that are typical for Northern Europe exist, such as winter-term inversion, high dust concentrations during spring time due to the winter sanding and long range transportation episodes when ozone or smoke (high particulate concentrations) originated from the forest and land fires from Eastern Europe are transported into the country with the wind flow.

Traffic is mainly causing the poor air quality situations in Finland. The annual limit value for NO_2 (came into force in 2010) was exceeded in Helsinki in one monitoring site in the city center in year 2010, 2011 and 2012. Thus, Finland applied for the extension period for the limit value and five years postponement time was given by the European Commission.
(http://ec.europa.eu/environment/air/quality/legislation/time_extensions.htm)

The long-term time-series of air quality measurements show that there is slightly decreasing trend in the pollutant concentrations in the air in Finland. However, the increasing traffic volumes in Helsinki metropolitan region and the growing popularity of diesel cars in recent years are causing difficulties to meet the annual limit value for nitrogen dioxide in the city center and street canyon environments in Helsinki. The city of Helsinki has air quality improvement program (2008-2016) which was launched in spring 2008. It is aiming to reduce the concentrations of road dust, fine particulates, nitrogen dioxide and greenhouse gas pollution.

The actions are targeted to the traffic and movement; planning, public transportation, cars, walking, cycling and ship traffic. In case of road dust the formation of the dust should be prevented, methodologies for de-icing are considered, responsibilities and methodologies for cleaning the roads are considered, the special attention is also in constructions site’s dust control. The information about house heating alternatives and their effect to the fine particulate concentrations in the air are disseminated-

In St. Petersburg area

The air pollution is the key factor of the environmental impact in St. Petersburg. The air quality depends mainly on pollutant emissions from industries and traffic. Based on the Air Monitoring System data, the average annual concentrations of major pollutants in St. Petersburg, given in fractions of Maximum Permissible concentrations (MPC) for the period from 2008 to 2012 are presented in Table 1 and the Maximum permissible Concentrations for these compounds are presented in the Table 2. MPCs in the Russian legislation are the limit values established for pollutants. MPCs are defined for more than 1300 compounds in Russian Federation. MPC is the maximum concentration of a substance, which does not affect human health and its progeny, as well as the components of the natural ecosystem.

Table 2.1. The highest Annual Mean Concentrations in fractions of Maximum Permissible Concentrations of Main pollutants in St. Petersburg.

Year	**NO_2**	**NO**	**CO**	**SO_2**	**PM_{10}**
2008	0,9	0,5	0,2	0,2	0,7
2009	0,9	0,5	0,2	0,2	0,5
2010	1,0	0,5	0,2	0,2	0,6
2011	0,9	0,5	0,1	0,2	0,5
2012	1,0	0,5	0,2	0,2	0,6

Table 2.2 Maximum Permissible Concentration levels for most common pollutants in the city of St. Petersburg.

NO_2	**NO**	**CO**	**SO_2**	**PM_{10}**
40 $\mu g/m^3$	60 $\mu g/m^3$	3 mg/m^3	50 $\mu g/m^3$	40 $\mu g/m^3$

The air quality assessment leads to the following conclusions:

- the average annual concentrations of the major pollutants – nitrogen dioxide, nitrogen monoxide, carbon monoxide, sulphur dioxide, PM_{10}, as well as 3,4-benzo(a)pyrene, ammonia, aromatic hydrocarbons, did not exceed the MPC level in the period from 2008 to 2012;
- based on maximum 20-30 min data, the values of the air pollution with nitrogen oxides, carbon monoxide, PM, ozone, in the central part of the city can be characterized as “elevated”;
- nitrogen oxides, ozone and PM are greatest contributors to the city’s air pollution;
- average concentrations of nitrogen oxides, carbon monoxide and sulphur dioxide in remote districts of St. Petersburg are twice and more as lower than those in the central districts, while PM_{10} average concentrations are almost similar in remote and central districts.

The model calculations showed that only for nitrogen dioxide the daily average MPC value may be exceeded. The correlation coefficient between modeled and measured values at the monitoring stations sites varies from 0.84 to 0.92, which shows that modeled data are adequate. The area of the city, where the NO_2 pollution is exceeded, amounts to 8 % of the total city’s area.

As the only pollutant whose concentration is systematically exceeded at 8.5% of the city's area, is nitrogen dioxide, the major task/target of St. Petersburg is to decrease this area. In 2012 "Main direction of the Environmental Policy of St. Petersburg to the year 2030" was drafted. The document contains a chapter on the main directions of the air protection.

To improve the air quality the following measures have been taken in the city:

- Gradual removal of 139 industrial companies from the central part of the city;
- Completion of the implementation of major 7 projects on traffic infrastructure development, which have a positive impact on the air quality;
- A requirement was set that all public transport purchased for the city should meet EURO4 standard;
- District heating installations of Petrodvorets, Petrogradsky, Kurortny, Primorsky, Vasileostrovsky disctricts were upgraded;
- Four bigger electric and heating plants were upgraded;
- Relevant activities are implemented to check and ensure the compliance of companies to the air protection legislation.

3.4 Status of the AQM system in St. Petersburg as of 2004

The St. Petersburg air monitoring automated system was established by the City Administration according to the Terms of Reference on Automated Air Quality Control and Management System in 1996. During the first stages of the pilot operation of the automated stations (since 1999) and the extension of the monitoring network in the framework of the first development concept (to the year 2007), it was referred to as the Automated Air Quality Control and Management System of St. Petersburg, or the AQM System.

In 2004 the AQM System included 12 automated stations located in 11 administrative districts of St. Petersburg, two meteorological stations, the station operation management center and the center of the information support of the public authorities. The stations were supplied with measuring equipment, mainly of domestic production. The auxiliary equipment and software were developed by various manufacturers and were not unified. In Figure 1, the Air Quality Monitoring network of the city of St. Petersburg is shown.

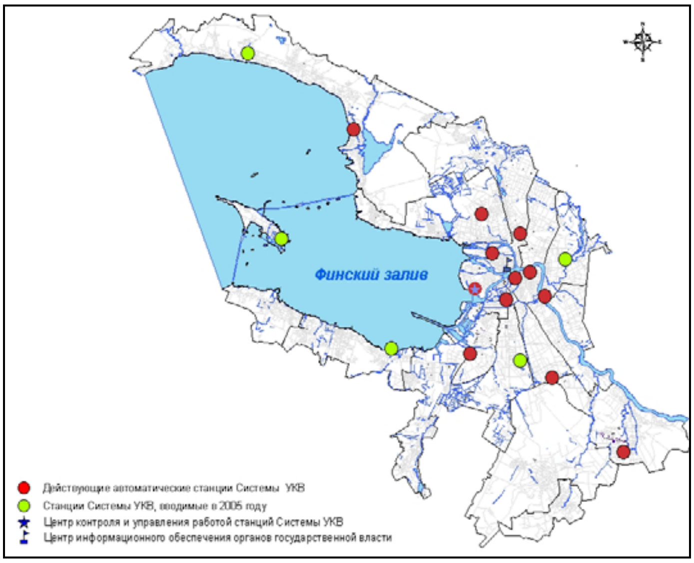


Figure 1. AQM System of city of St. Petersburg in 2004.

The AQM system passed the pilot operation and was being prepared for the operation and maintenance phase. The AQM stations were operating continuously and provided actual information about the level of the air pollution by major pollutants in St. Petersburg. At the same time, the information losses amounted to 30% due to organizational and technical reasons, while the data reliability required additional control using mathematical statistics criteria before its application. The total information data losses often exceed 50% after screening all questionable data. The automated data collection from AQM stations was carried out using the server with software developed by D.I. Mendeleyev VNIIM (All-Russian Scientific and Research Institute for Metrology). The Airviro software complex with v. 2.21 network version (for a limited number of users) developed by the Swedish Meteorological and Hydrological Institute was used for presenting and processing the obtained data.

Evaluation of the pilot operation of the AQM systems revealed:

- insufficient number of the air quality automated monitoring stations for modeling and detailed description of pollutant spatial distribution and concentrations throughout the city's territory;
- lack of information on the air pollution with fine suspended matter (PM_{10} and $PM_{2,5}$) in St. Petersburg;
- need in taking into account the increase of the air pollution in St. Petersburg by specific pollutants, primarily ammonia, formaldehyde and 3.4-benzpyren;
- insufficient stability in the operation of automated stations included in the AQM system.

In this regard, according to the Concept of the AQM System Development for the period from 2004 to 2007 (approved by the Committee for Nature Resources, Environmental Protection and Ecological Safety No. 67 dated December 22, 2003), it was planned to increase the number of automated air monitoring stations based on the “hybrid monitoring” principle: the network of automated pavilion-type stations should have been supplemented with smaller automated stations, multichannel portable passive sampling devices, mobile automated stations, the “objects monitoring” stations. It was planned to bring the total number of automated stations, including pavilions and small stations, to 20.

The location of the automated stations in the city was determined by the "Scheme of placement of the AQM System stations to the year 2010" which was developed by the Voeikov Main Geophysical Observatory on the Committee’s instructions in 2004.

Besides expanding of the observation network and the range of measured pollutants, the Concept of the AQM System Development implied:

- to ensure stable operation of the air monitoring stations of the AQM System through replacing the outdated instruments with modern equipment, establishing a reserve equipment pool to ensure continuous obtaining of environmental information, developing the software for measuring channels unification, equipping the stations with calibration and verification tools, organizing of the AQM data control systems;
- to put the AQM system into operation;
- to develop and integrate the methods for the air quality assessment and forecast to support managerial decision-making and to inform the public about the air quality in city (in particular, the development and maintenance of an operational interactive air pollution map, based on GIS of the Environmental Passport of St. Petersburg and AQM data);
- to use the AQM data for the air quality management in St. Petersburg (in particular, to develop the regulations for the AQM information product use and to develop software; to integrate the AQM information in the Environmental Passport of St. Petersburg).

To fulfill the new tasks it was necessary to organize operation and maintenance of the AQM system under the auspices of a company which would possess specialized technical resources - the AQM System equipment and a staff of highly skilled experts, and conduct its activities in accordance with the laws and regulations of the City of St. Petersburg. Starting from 2004 the AQM System is operated and maintained by the St. Petersburg Specialized State Unitary Geological Enterprise “Mineral”, which is supervised by the Committee and licensed by Roshydromet.

3.5 Expectations and targets for the Cooperation

In December 2003, a Declaration on cooperation was signed for the period 2004-2007 between the Ministry of Environment of Finland and the Committee for Nature Use, Environmental Protection and Ecological Safety the City of St. Petersburg, which served as the basis for the cooperation.

At the first stage, the Finnish and Russian sides got acquainted with the organization of the air monitoring in Finnish cities and in St. Petersburg; the assessment of the existing system of air monitoring and air quality control in St. Petersburg was made. The assessment included the following major issues: the current system of measurement (measuring stations and equipment, technical maintenance, data collection and distribution systems, procedures for quality assurance and control, data processing, management and reporting methods) and other methods of assessment of the air quality (e.g., inventory of harmful gaseous emissions and dispersion models).

Based on results of the first stage, the Project partners formulated the priorities and phasing of further cooperation, which included:

1. Optimization of the equipment used in the monitoring stations;
2. Increasing the number of measurement channels, extending measurement methods (passive sampling);
3. Methodological support of the system's operation;
4. Metrological support of the monitoring system;
5. Optimization of the data processing system;
6. Development of modeling methods using filed monitoring data;
7. Organization of monitoring data presentation to various target groups, including the general public;
8. Developing of a system for data exchange between the project participants with the potentiality to extend the number of participants in the data exchange.

The implementation of these priorities built the basis for further cooperation. At each stage, the outlined priorities were realized consistently, which eventually brought the automated air monitoring system of St. Petersburg to the acceptable European standards in terms of hardware, methodology and metrology.

3.6 Russian standards for monitoring

According to the Russian Federation legislation, the ambient air monitoring operations are subject to licensing. The State Unitary Enterprise "Mineral", which operates and maintains the automated air monitoring system of St. Petersburg, from 2004 to 2008 had the license of the Federal Service for Hydrometeorology and Environmental Monitoring Р/2004/0012/100/Л dated 06.02.2004, and on 21.11.2008 a new license Р/2008/1427/100/Л was obtained, which is valid till now.

There are no strict legal regulations for the automated air monitoring network concerning the number of the stations. The location and number of the automated stations in St. Petersburg were determined following the recommendations of the Voeikov Main Geophysical Observatory in the "Scheme of placement of the AQM System stations to the year 2010".

Meeting the Russian standards in terms of accuracy of the measurements: The laboratory for environmental monitoring of “Mineral” complies with the requirements of the Russian Standard GOST R ISO/MEK 17025-2006, as well as with the criteria of the technical competence in the relevant area of accreditation by the System of Accreditation of Analytical Laboratories (Accreditation Certificate of Rostechregulation № POCC RU.0001 515825). The recent inspection to check the compliance with the accreditation requirements was carried out by the Federal Accreditation Service of the Russia Ministry for Economic Development in June 2012.

As following the license requirement, “Mineral’ gives the data of the Automated Air Monitoring System of St. Petersburg to the Unified State Database of Environmental Data.

4 PROJECT MANAGEMENT

4.1 Project Partners and Financiers

Finnish Project Partners

Baltic Institute of Finland (BIF), has been the project coordinator and responsible for the project management during four (2004 - 2011) project phases. BIF has expertise on project coordination.

The Baltic Institute of Finland (BIF) is a non-profit organization owned by the city of Tampere. BIF has operated since 1994 and is specialized for project management. BIF’s core activity is to promote cooperation and concrete projects between organizations operating around the Baltic Sea Region and throughout Europe. BIF’s mission is to create and enhance international cooperation networks between citizens, researchers, experts, authorities and businesses in their efforts to identify new partnerships and activities. BIF’s role in the AQM project has been the project coordination (2004 – 2012).

Finnish Meteorological Institute (FMI), air quality expert organization in Finland has provided the practical knowledge and expertise on air quality assessments (instrumental monitoring, data management, passive sampling, dispersion modeling), emission inventories and air quality legislation in European level to the project. FMI’s role in the project has been the implementation and air quality expertise.

Finnish Meteorological Institute is governmental organization that operates under the Ministry of Transport and Communications. FMI is the official air quality expert organization in Finland. Currently, over 650 employees work in FMI, which approximately 70 experts working in air quality related work. FMI has over 40 years of experience on the air quality monitoring and the dispersion modeling and the development of the models. The first air quality monitoring network was founded in 1970’s when environmental protection began to make rapid progress.

FMI is responsible of the background air monitoring in Finland. Currently, FMI has 13 fixed background air quality monitoring stations and in addition a number of air quality monitoring stations that are used for consulting services or research projects. FMI manages the national air quality database and reports all national air quality data to European Union annually. FMI also maintains the air quality portal (www.airquality.fi) where all the national air quality monitoring data is available to public. FMI has the national reference laboratory of Finland which offers quality control and assurance support to air quality monitoring networks in Finland. FMI has had air quality related projects in over 20 countries worldwide. Therefore, FMI has strong expertise on air quality management systems, instrumental monitoring including QC and QA of monitoring and dispersion modeling model development and different dispersion modeling applications. In the AQM cooperation project, FMI's role has been the implementing expert organization.

Finnish Ministry of the Environment (MoE) is the highest governing body in environmental administration. The Ministry is responsible for strategic planning and management in its administrative area, the drafting of new legislation, and international co-operation on environmental issues. Ministry of the Environment has financed and supervised this project.

Other partners

Cities of Imatra and Tampere were involved in the first phase of the project. In the beginning of the project the City of Tampere handed over the project coordination to BIF. City of Imatra shared their experiences on air quality monitoring and cooperation with Svetogorsk.

Helsinki Region Environmental Services Authority (HSY, former YTV) is a regional authority providing environmental services for residents and companies in the Helsinki area. HSY is responsible of air quality monitoring in the Helsinki Metropolitan region and information distribution to public in the Metropolitan area. HSY was involved as partner in the 1st phase of the cooperation with informing residents (public awareness) and after that HSY has been partly involved for the online data exchange and information exchange in some of the project activities.

The Finnish Air Pollution Prevention Society (FAPPS) is a national environmental protection society. Its purpose is to prevent air pollution. In Finland FAPPS also promotes research on air protection. FAPPS connects people and communities working with air protection in Finland and abroad. FAPPS was founded in 1976 and counts about 420 members and near 30 societies FAPPS is a member of the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) and The European Federation of Clean Air and Environmental Protection Associations (EFCA). Every year the FAPPS organizes the Air Quality Days (Conference) in Lappeenranta and Air Quality monitoring Meeting in variable locations in Finland. Russian project partners have visited in Lappeenranta air quality days in 2005, 2007 and 2009 and also the air quality monitoring meeting in 2006. The AQM project was presented in Air Quality days Conference in Lappeenranta in 2011 and few months later FAPPS organized study visit to the City of St. Petersburg which Committee was hosting.

Russian partners

Committee for Nature Use, Environmental Protection and Ecological Safety of the city of St. Petersburg's is a public authority of the local level, whose responsibilities range from the city's environmental policy development and implementation to very practical activities like establishment and management of the environmental monitoring systems in the area of St. Petersburg. The Committee often applies innovative approaches to the environmental management. To a great extent those innovations are inspired and supported by the international cooperation, which is been developed quite intensely since 1993. The Committee's role in the project has been financing, implementation and air quality expertise.

The State Geological Unitary Enterprise "Specialized company "Mineral" (S.C. Mineral) implements activities related to the air monitoring in St. Petersburg, maintains the geoinformation system "Environmental Passport of St. Petersburg"; carries out geological mapping, environmental, geophysical and geochemical studies in North-Western Region of Russia. Mineral's role in project has been the practical implementation of the comparison monitoring exercises and the QA and QC work related to the air quality monitoring. Mineral has also important role in the online data exchange.

Figure 2. State Company Mineral's mobile unit for air quality monitoring

The D.I. Mendeleev All-Russian Institute for Metrology (VNIIM) is the successor of the Main Chamber of Measures and Weights which was the first in Russia among metrological institutions. It is the leading Russian organization in the field of precise measurements in metrology and the major center of national measurement standards in Russia. VNIIM's role in the project has been the analysis of the VOC samples collected by Mineral.

The Voeikov Main Geophysical Observatory is the oldest meteorological institution in Russia. MGO is the Russia's pioneer in climatology, dynamic meteorology, aerology, and actinometry, a number of atmospheric physics disciplines, atmospheric diffusion and air pollution research. The MGO objective is research and development in various fields, among them monitoring of the atmospheric condition and air pollution, methods development for creation and operation of atmospheric condition and air pollution monitoring networks. MGO is the Roshydromet's steering center for the monitoring of air pollution and background air composition.

Research Institute for the Air Protection – NII Atmosfera is the research and methodology center in the area of the ambient air protection. The key fields of activities of the Institute are: development of science and methodology substantiation for emission permits; environmental impact assessment in air protection activities; science and methodology support to monitoring of the air pollution sources; development and coordination of research and experimental-design activities in creation of new technical means and methods for emission monitoring; collection and assessment of information on pollutant emissions in the territory of Russia; science and methodology support of the air protection activities of regional agencies of the Russian Ministry of Nature Resources and Ecology; training in air protection activities; studies in the environmental impact of air pollution sources.

“Integral” Company is Russia's market leader in the development of the environment protection related software with an over 20-year-long experience. Among the software products for environmental experts there are software for calculation, for database management, for making-up of documents according to standard forms; reference software – in the field of the air protection, among others. In the wide range of Integral’s development there are unique products, and “Ecolog-City”, software for integral air pollution assessment in a city/region scale, is among them. Another field of “Integral’s activity is professional training of experts in environmental protection.

5 OBJECTIVES AND MAIN ACTIVITIES

The AQM cooperation has included many project phases (four actual project phases + evaluation phase) and various activities dealing with the improvement of air quality assessment methodologies and information exchange.

The objectives of the cooperation were:

- Decrease and prevention of trans-boundary emission threatening the environmental conditions of Baltic Sea and Finland
- Harmonization of the legal framework of environmental management and strengthening of the capacities of institutions responsible for environmental managements and control.
- Strengthened and more holistic consideration of environmental issues in planning, decision making, implementation and monitoring of economic activities and investments in various sectors.
- Raising the environmental awareness

At the first project phase the project was designed to enhance reduction and prevention of emissions to the environment in Baltic Sea area with special emphasis on improvement of air quality in the St. Petersburg region. In practice, this meant practical level collaboration between cities and experts to identify needs and opportunities in developing air quality monitoring system and information distribution to citizens as well as to create basis for continuous exchange of information and experiences.

The first phase (2004 – 2006) of the project included mostly the exchange of information of the air quality monitoring and managements systems at the time and getting acquainted. The following project phases included more concrete level practical work. Each project phase included the recommendations for the future cooperation which were based on the experiences and findings during the cooperation.

The objectives from the beginning of the project have been all met during the cooperation project. The project has increased the knowledge and monitoring of the dispersion of trans-boundary emissions by initiating the online information exchange between the background monitoring stations in St. Petersburg area and Finland. In the project the ship emission impacts; ship emission inventory and the impact of ship emissions to air quality has been studied and totally new methodology for assessing the ship emission's was developed during the project. Ship traffic is considerable emission source in Baltic Sea area and it also causes trans-boundary emissions.

The key activities of the AQM project have been dealing with then strengthening of the capabilities of institutions responsible for environmental management and control. In St. Petersburg, the air quality monitoring and assessment methods have been improved and new legal documents and recommendation have been created. The use of air quality data in decision making processes has been increased.

Harmonisation of the legal framework between the Finland and Russia is a challenging due to the differences in legislative systems and data management policies. However, the legislative principles in both countries have been introduced and discussed and some similarities in the legislative framework between the countries have been found.

The project results have been disseminated for wide audience in both countries. Thus, raising the environmental awareness has been done by disseminating the project results and experiences both in Russia and Finland (i.e. The Ecology of Big City Exhibition in St. Petersburg and annual Air Quality Days in Lappeenranta.

The first project phase included the introduction of the project partners, organisations involved and the air quality managements systems in Finland and St. Petersburg area. The following projects included more concrete practical work. Most of the practical work has been done under the following topics;

- instrumental monitoring
    - Passive Sampling and analysis (VOC's)
    - Comparison of the sampling techniques
    - Calibration and data handling
    - Quality Control (QC) and Quality Assurance (QA)
    - Comparison measurements
    - Staff Exchange and training
    - Foundation of background monitoring station
    - Online data exchange

- local scale dispersion modeling
    - Emission databases
    - Comparison modeling exercises
    - Dispersion calculations for point sources
    - Dispersion calculations for traffic emissions
    - Ship emissions (ship emission inventory)
    - Dispersion modeling applications

- Other additional topics
    - Greenhouse gases
    - Climate change
    - Noise
    - Visit in European Chemical Agency (ECHA) in Helsinki

These activities are described more detailed in following chapters.

6 INSTRUMENTAL MONITORING

6.1 Improvement of the monitoring network, equipment of the stations and enlarging the scope of measured parameters

The automated Air Monitoring System of St. Petersburg (AMS) was established by the City Administration in 1996 and is owned by the City. The AMS comprises two levels: the measurement unit and information service. The measurement unit integrates:

1. the measurement network (automated stations, mobile measurement laboratories)
2. technical service (means for technical and metrological maintenance)
3. the management centre (data collection, data quality check, data processing, database updating).

The information service implies air quality assessment, data presentation etc.

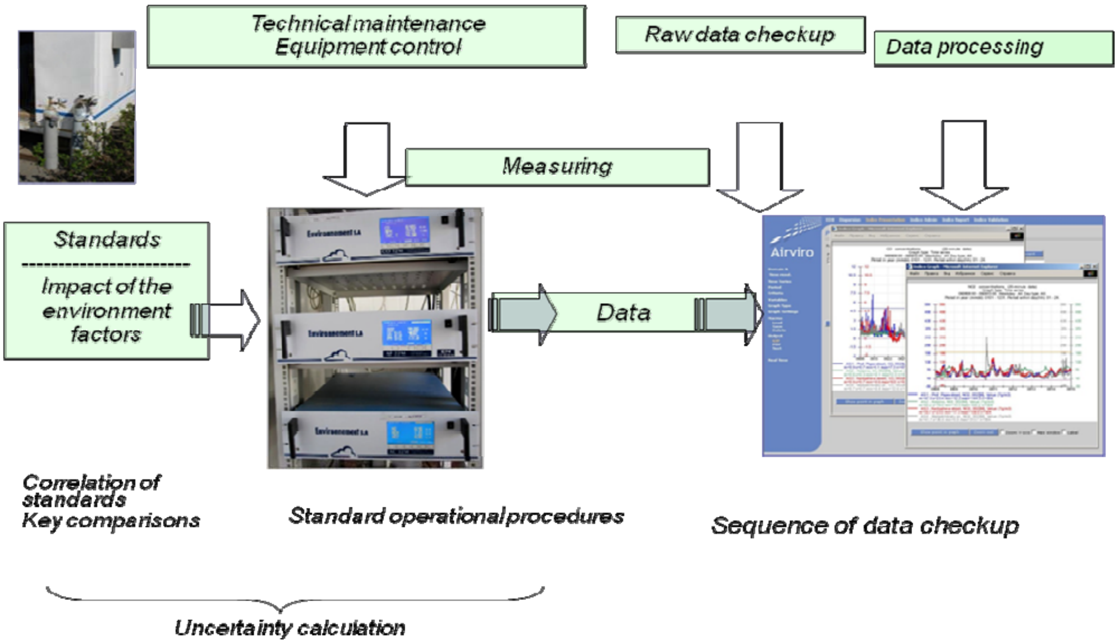


Figure 3. Schematic picture of the measurement unit and the information service.

The following tables 3 – 6 describe the St. Petersburg AMS development during each AQM cooperation phase in terms of equipment, improvement of the monitoring network, enlarging of the scope of measured parameters.

In the 1st cooperation phase the major activities were targeted at getting acquainted with existing AM systems, assessment of their efficiency, identifying needs for development and improvement. Therefore, this cooperation phase is characterized by intensive contacts, consultations, meetings and workshops. Many recommendations were given by the Finnish experts at that phase. The AMS network grew from 12 to 17 automated stations and 2 mobile laboratories were added. Passive samplers were tested in St. Petersburg based on Finnish experience; PM_{10} measurements were launched at 9 more stations.

Air quality related legislation and standards of both countries were compared. The article on the air quality assessment in Saint Petersburg according to EU Directive indicators was published in 2005 in “Ilmansuojelu” FAPPS Magazine.

Table 3. 1st Cooperation Phase (11.2004-01.2006, 15 months)

AMS development tasks, solved within the Project's frames, recommendations	**Achievements in AMS development**
Atmospheric air monitoring system assessment (Unification of approaches: location and types of the stations, quality and data completeness requirements, metrological procedures, harmonization of EU and the Russian Federation systems). Consultations and practical workshops, Distribution, Data application (using the best practice examples of Finish cities, organizing the monitoring system in YTV (Helsinki) The Moreenia Information Center in Tampere. Preparation of joint Finnish-Russian monitoring data publications Recommendations on expanding the PM measurement system using new strategy and increasing PM_{10} as well as $PM_{2.5}$ number of observations at some monitoring stations. Remarks on locating some transport monitoring stations (away from carriageway). Recommendations on daily span monitoring, control and filter replacement at input gas analyzing lines, preparation for balance uncertainty assessment, documenting software Recommendations to organize comparative measurements to demonstrate comparability of results	Twelve automatic air quality monitoring stations were included in the AMS system on January 1, 2004 In 2004, five new stations, two mobile laboratories and one mobile technical maintenance laboratory were established. In 2006, 17 automatic stations, 2 mobile laboratories, one mobile technical service laboratory, 5 passive sampling stations, 14 devices for 3,4 benzpyrene samplings were included in the AMS system. From November , 2004 to January, 2006, the domestic-made gas analyzers had been replaced using foreign-made devices produced by the ThermoElectron Corp. 58 gas analyzers and 12 PM_{10} Dust analyzers were included in the AMS system By that time, there was 69 percent of foreign-made Equipment. According to experimental operational results obtained in 2006, the automatic sampler of fine- dispersed suspended matters (PM_{10}, $PM_{2.5}$) PNS 3.1/6.1-15 produced by Norbert Derenda Engineering office (Germany) was recognized as a promising brand for equipping the AMSs. Another four PNS-3.1/6.1-15 sets and a portable-analyzer set for APM-2 for determining simultaneously and automatically the PM_{10} $PM_{2.5}$ particle content have been purchased. The article "Air quality systematic estimation in Saint Petersburg according to EU Directive indicators" (using the 2004 data) was prepared in 2005 in "Ilmansuojelu" FAPPS Magazine

The 2nd cooperation phase was very practical. The quality of the monitoring data was one of great concerns, therefore, metrology issues were in focus. The data losses decreased appreciably as a result of the joint activities: from 30% in 2004 to 8% in 2007. Comparative measurements campaigns were launched based on recommendations of the previous cooperation phase. 2 more automated stations were added to the network, systematic observations of PM_{10}, phenol and formaldehyde started.

Table 4. 2nd Cooperation Phase (06.2006-12.2007, 18 months)

AMS development tasks, solved within the Project's frames, recommendations	**Achievements in AMS development**
The practical cooperation phase Purpose - 1. Monitoring stations network improvement, measured parameters spectrum enlargement; 2. Passive sampling introduction; 3. Received information quality upgrading; 4. Metrological system supply improvement. Practical trainings in developing the measurement system, passive sampling. Joint measurements of gaseous pollutant comparison: nitrogen oxides, carbon oxide (Station No.: 4 - Transport), sulfur dioxide, ozone (Station No.: 9 residential and industrial air pollution) and quality maintenance procedures in measurement operations. VOCs comparative measurements - Stations No.: 4 and No.: 9. Passive sampling, training workshop in St. Petersburg, Passive sampling comparative measurements from October 2006 to May 2007. Maintenance measurement workshop, gaseous compound comparative measurements from February 2007 to May 2007. Workshop on comparative measurement results. According to VOC, it was recommended to enlarge the set of defined substances such as styrene, propylbenzene, ethyl toluene and trimethylbenzene (the ozone formation, acc. to the Directive, it is recommended to measure the concentration of 29 substances) Recommendation of a mass-selective detector.	Two new automatic stations have been introduced in AMS structure. Thus, the total number of AMS automatic stations has reached 19 units. The primary measuring equipment park made up 87 units by the end of 2007. Reserve equipment park was formed in 2007. The reserve equipment made up 15% of the total gas analyzers. Using the experience of Finnish colleagues, passive sampling selection and validation methods have been chosen and certification, as well as the sorbent selection. In 2006, monitoring of aromatic hydrocarbons in St. Petersburg atmosphere using passive sampling techniques has been launched. In 2007, systematic observations of PM_{10}, phenol and formaldehyde content have been launched. The number of PM^{10} measurement channels at the permanent stations has reached 16 units, as well as two sets of analyzers in mobile laboratories have been acquired. The data losses have been decreased to 8% at the stations in 2007, while according to the assesments, they reached 30% in 2004, 15% in 2005 and 10% in 2006

Two highlights were characteristic for the 3rd cooperation phase. 1st was: an important initiative of establishing the background data on-line exchange: developing of a protocol and launching. Second emphasis was put on strengthening of the QA/QC activities; the SOP for St. Petersburg AMS was developed by the Finnish experts.

Table 5. 3rd Cooperation Phase (08.2008-02.2010, 19 months)

AMS development tasks, solved within the Project's frames, recommendations	**Achievements in AMS development**
1. Practical cooperation between the monitoring stations concerning atmospheric air background pollution and interactive mutual information exchange (exchanging the program experience in monitoring, measuring methods, installing the equipment, operating the stations, consulting background monitoring organizations); 2. Organization of interactive mutual information exchange (Background monitoring data); 3. Practical cooperation in developing the quality assurance and quality control systems (QA / QC): development of Standard operating procedure guidelines (SOP) and their application, methodological assistance in establishing the GGUP "Mineral" metrological group, intercalibration at VOC measurements, comparative concentration measurements of suspended particles. 4. Audit of background monitoring stations (2010).	Two new automatic stations have been introduced in AMS structure. The total number of automatic AMS stations has reached 21 units. In 2008-2009, the work of the monitoring station (in Shepelevo) was organized on the background level and the data exchange was established. In March 2009, the data exchange agreement between background monitoring stations located in Finland and Russia was concluded. With that end in view, the background monitoring station work was organized in the Kandikyulya Settlement (The Shepelev Cape). In 2008-2009, the remaining domestic-produced measuring devices were replaced by the "Environment S.A" and "Ingenieurbüro Norbert Derenda" equipment. In 2008, 107 units of domestic and imported equipment and in 2010 - 87 units have been substituted in the stock of the main measuring equipment. In 2010, the stock of the reserve equipment made up 14% of the total gas analyzers. In 2010, the number of the sampling points collecting volatile organic compounds (VOC aromatic hydrocarbons, phenol and formaldehyde) and 3,4 -benzpyrene was 12 units. The number of PM_{10} measurement channels was 12 (+2 at the mobile laboratories). The number of $PM_{2.5}$ measurement channels was 4, one of them was in Shepelevo. In connection with the planned measuring equipment substitution and poor air-conditioning at the AMS stations during the summer period, the information losses reached 12.5% in 2010.

The 4th cooperation phase was dedicated to strengthening, further development and improvements in all fields of activities launched in previous phases. Besides, the ever first attempt of assessment of the impact of the air pollution by ships was made in St. Petersburg. InnoShip project was launched.

Table 6. 4th Cooperation Phase (06.2010-02.2012, 21 months)

AMS development tasks, solved within the Project's frames, recommendations	**Achievements in AMS development**
1. Practical cooperation in instrumental monitoring and information exchange between the background stations in real-time mode; 2. Air pollution monitoring in the areas subjected to water transport discharges; 3. Exchange of information on VOC measurement techniques and technology; 4. Carrying out comparative gas pollutant measurements in St. Petersburg (ozone, nitric oxide, sulfur dioxide), the analysis of PM_{10} samples containing polyaromatic hydrocarbons; 5. Measurement order improvements (Standard operation procedures), uncertainty measurement calculations.	In 2011, there were 21 automatic stations, 2 mobile laboratories, one mobile technical service laboratory, 12 VOC sampling points, 13 devices, sampling 3,4-benzopyrene. The main measurement devices stock reached 94 equipment units, 10 equipment units were in reserve. The data losses reached 7%. The new instrument for VOC sampling taken into use. The AMS stations have been equipped with more sophisticated automatic systems stabilizing power supply and temperature measurement Parameters. $PM_{2,5}$ systematic monitoring has begun. The universal station monitoring AMoS gas and dust air content has been tested within the AMS frames.

The tasks solved within the Project's frames have made a positive impact on AMS development. The main parameters characterizing the AMS development within the cooperation periods are presented in Tables 7 – 8.

The greatest influence on developing the AMS cooperation has been exerted in the following areas:

- Improvement of monitoring network content and structure;
- choosing the best types of equipment and the best experience of its servicing;
- establishment the VOC monitoring subsystem;
- stock reserve equipment establishment;
- development and improvement of AMS metrological experience;
- creation and development of PM and PM monitoring subsystems;
- data loss reduction and compliance with EU data quality requirements;
- establishment of monitoring stations at the background and data exchange levels.

Table 7. AMS development in cooperation periods

Periods	**Beginning in 2004**	**2006**	**2008**	**2010-2011**
Number of stations	12	17	20	21
Number of analytical equipment units	32	70	107	94
Analyzers reserve stock	0	11	32	12
Volatile organic compounds sampling points	0	5	10	12
3,4-benzpyrene sampling points	0	14	15	12
Data losses, %	30	10	6	7
Observed pollutants	10 carbon oxide, nitrogen oxide, nitrogen dioxide, sulfur dioxide, suspended particles (TSP), PM_{10}, ammonia ozone, benzene, toluene	11 carbon oxide, nitrogen oxide, nitrogen dioxide, sulfur dioxide, suspended particles (TSP), PM_{10}, ammonia ozone, benzene, toluene, 3,4-benzpyrene	15 carbon oxide, nitrogen oxide, nitrogen dioxide, sulfur dioxide, suspended particles (TSP), PM_{10}, ammonia ozone, benzene, toluene ethylbenzene, xylene sum, phenol, foPMaldehyde, 3,4-benzpyrene	15 carbon oxide, nitrogen oxide, nitrogen dioxide, sulfur dioxide, suspended particles (TSP), PM_{10}, $PM_{2.5}$ ammonia ozone, benzene, toluene ethylbenzene, xylene sum, phenol, foPMaldehyde, 3,4-benzpyrene

Table 8. Development of AMS suspended particles monitoring subsystem

Year Channels	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
PM_{10}	2	2	2	11	12	15	14	12	13	13
TSP	-	2	2	6	5	4	2	0	-	-
$PM_{10_{2.5}}$	-	-	-	-	-	-	1	3	6	6
Total	2	4	4	17	17	19	17	15	19	19
Equipment	Dust Track (TSI) IKP (VNIIM)			"Dust" (VNIIIM)			(PSN 3 1/6/1-15) Norbert Derenda, Germany			

The table illustrates a rapid development of the AMS capacity in measuring Particulate Matter in St. Petersburg. In the beginning of the cooperation only total dust and PM_{10} were measured at 2 sites. Starting from 2009 $PM_{2,5}$ measurements were launched at 1 station with Norbert Derenda equipment, while PM_{10} measurement canals were established at many more stations.

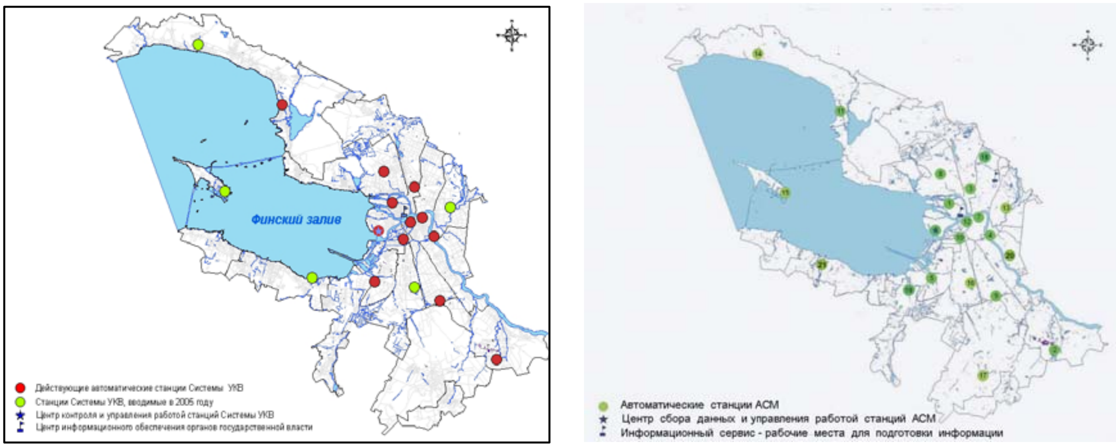


Figure 4. The Development of AQM system of St. Petersburg between 2004 (left) and 2011 (right)

Lessons Learnt

The long-term cooperation has offered a unique opportunity to know how the air quality network has been organized in a big city like city of St. Petersburg. It has been interesting to see and to be involved to the process to cover the large city area by monitoring units, select and evaluate the siting and to get familiarized with the installation of the stations.

Finnish Air Quality Experts have been involved in the development of the AQM system of the city of St. Petersburg. The cooperation between experts has been fruitful and both partners have gained a new information and knowledge during the project activities.

Currently, the city of St. Petersburg has more air quality monitoring stations than in Helsinki Metropolitan region, which has seven fixed air quality stations and four mobile monitoring stations, which are relocated yearly (HSY, 2013). The monitoring stations in St. Petersburg have been placed and classified according to the local criteria which are partly similar to EU siting criteria for air quality monitoring stations. The monitoring equipment and measurement methodologies for gaseous components and particulates are the same that are used in Europe. The differences between Finland and St. Petersburg are in data management, maintenance and calibrations operations of the monitoring equipment.

6.2 Comparison Measurements

When the calibration of the measurement instrument is linked to national standards or to the SI unit the comparability of the measurement results follows based on the definition. However, to demonstrate the comparability of the measurement results in St. Petersburg against those of the FMI in practice, the comparison exercises using with different measurement methods, different calibration methods and standards were conducted for the measurement results of major pollutants.

The first comparison for gaseous compounds was conducted in 2007 in St. Petersburg for ozone (O3), carbon monoxide (CO), nitrogen oxides (NOx) and sulphur dioxide (SO2) measurements. The second comparison for ozone measurement was conducted at the FMI while the second comparison for NOx and SO2 measurement was conducted in St. Petersburg. The comparison measurements for particulate matter (PM_{10} and $PM_{2.5}$) were conducted at two stations in the AQM network.

The first comparison of gaseous atmospheric pollutants in St. Petersburg

The protocol for the comparison exercise was agreed during the meeting at the State Company Mineral in September 12 – 13, 2006. The stations for the comparison experiments were selected after survey to the candidate stations. Based on the survey, the station no 4 was selected to represent as a traffic station and station no 9 was selected as a residential and industrial area. The comparison was conducted for oxides of nitrogen and carbon monoxide at the traffic station and ozone and sulphur dioxide at station no 9. Location of the two stations is shown in Figure 4. A training course to the personnel from the State Mineral Company was performed before the measurement campaign started. The training course took place at the FMI during January 31 – February 2, 2007 including Calibration methods for ambient air analyzers, definition of the NO2 converter efficiency by gas phase titration method (GPT) and maintenance of the gas analyzers (Thermo Electron Instruments, TEI C-series).

At the station 4 the oxides of nitrogen were measured with two identical TEI 42C analyzers (by Thermo Environment, USA) based on the chemiluminescence method. The analyzer is equipped with two channels: NO- and NOx-channels which analyses the sample in sequences. The nitrogen monoxide is measured directly by the chemiluminescence method but nitrogen dioxide is gained by converting first the nitrogen dioxide in the sample into the nitrogen monoxide and measuring the sum of nitrogen dioxide and the nitrogen monoxide (NOx = NO + NO2). The concentration of NO2 is then reached by subtracting NO from total sum of NOx. The carbon monoxides were measured also with two identical TEI 48C analyzers based on IR gas filter correlation method. The comparison for NOx was conducted during May 15 to June 26, 2007 and for CO the comparison was between April 6 to June 26, 2007.

At the station 9 the concentration of sulphur dioxide was measured by two identical Environment AF 22M analyzers (Environment S.A., France) based on UV-fluorescence method. The concentration of ozone was measured with Dasibi 1008AH by the FMI and TEI 49C by the “Mineral”. Both ozone analyzers were based on UV photometric method. The comparison for SO2 was conducted during May 15 to June 26, 2007 while in case of ozone it was due to the loss of data in the data acquisition system only during May 15 to May 25, 2007. All the measurement methods that are applied with the analyzers are the reference method defined by the EU directives (2008/50/EC).

During the comparison the calibration practise and capability was different between the partners. The calibration concentrations prepared by FMI for each of the gas com-pounds were within the measured ranges while in case of the MINERAL the calibration concentrations were much higher than the measured concentrations. The FMI made correction of measured results by mathematical equation obtained by calibration while MINERAL adjusted the respond of the analyzer based on the calibration.

In figure 5.1 the corrected daily averages of all pollutants compared in the first comparison exercise is shown. From the 1 hour averages no exceedances of the limit values by EU regulations were observed. Largest discrepancies of daily averages are observed in case of NO measurement results while in case of ozone the results are closer to each other

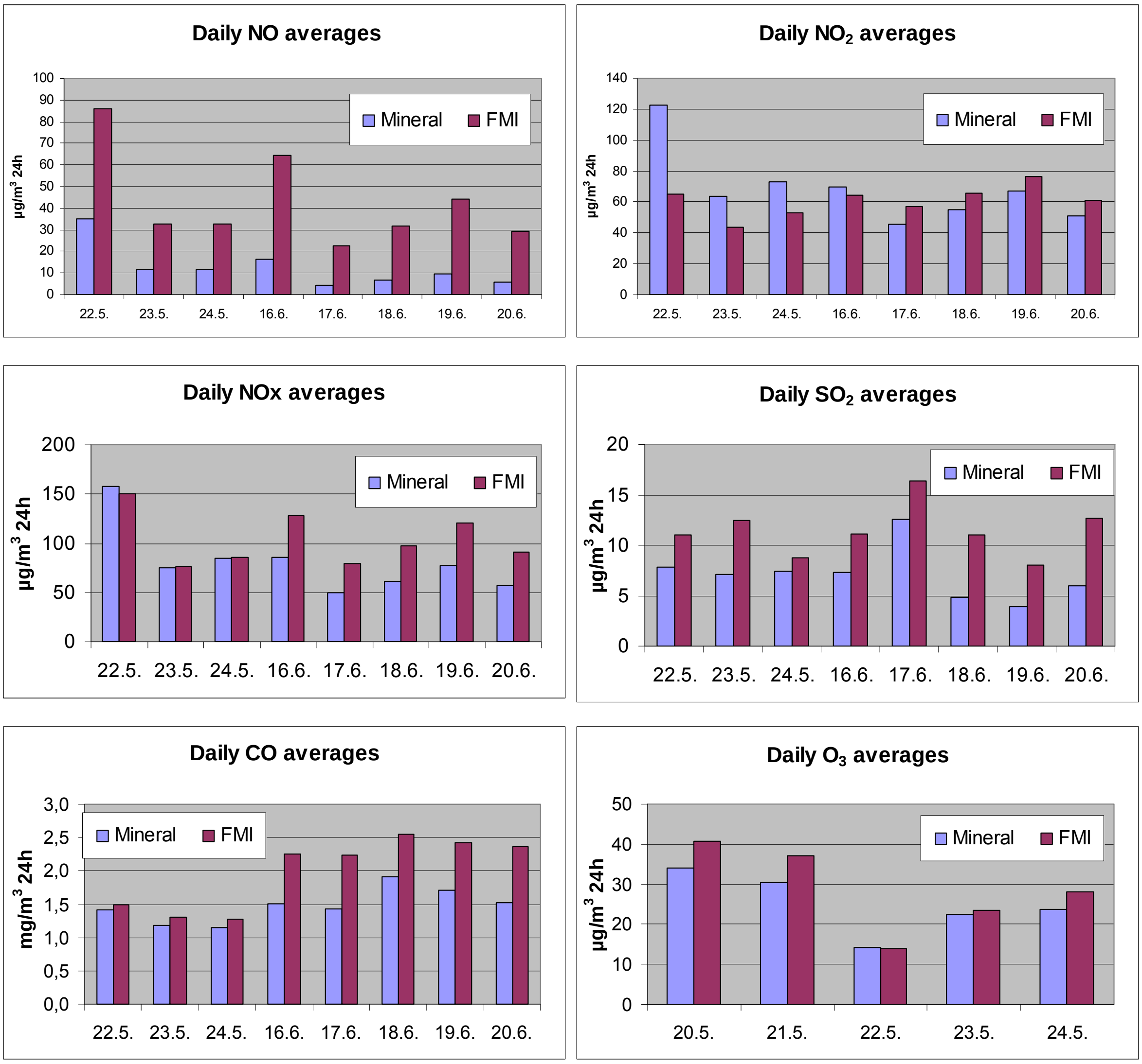


Figure 5.1. The corrected daily averages by both partners for all gas pollutants during the comparison for gaseous compounds.

PM comparison

The PM comparison was conducted according to the project plan of the AQMIII in autumn 2009. The objective of the study was to seek the conformity of the PM measurements conducted at the automated air quality monitoring network in St. Petersburg, with the PM measurement method conducted according to EU regulations. The size class for both of $PM_{2.5}$ and PM_{10} i.e. for particles with size less than 2.5 µm and less than 10 µm in aerodynamic diameter were tested in the comparison which included a background station of Shepelevo and a traffic oriented station in St. Petersburg.

The instrumentation at the comparison consisted with automated PM samplers, Derenda APM-2, equipped with a nephelometer and an automated dust particle analyzer, Grimm #180. The nephelometer enables continuous concentration measurements of particles and was run by MINERAL. The FMI provided Grimm instrument for comparison which is designed for continuous measurements of the particle size and/or particle mass concentrations with optical method. The particle size fraction with Derenda APM-2, were classified into $PM_{2.5}$ and PM_{10} size fractions by specifically designed PM inlets according to the EN standards. In Shepelevo two Derenda instruments were used, one equipped with $PM_{2.5}$ inlet and the other with PM_{10} inlet. In St. Petersburg only one Derenda instrument was used with a sampling sequence of weekly changed PM inlets between $PM_{2.5}$ and PM_{10}. Only one Grimm instrument was used in both campaigns, since the Grimm instrument measures simultaneously $PM_{2.5}$ and PM_{10} size fraction. The equivalence of the Grimm #180 instrument has been tested against the reference method of $PM_{2.5}$ and PM_{10} by FMI (Walden et. all, 2010).

Based on the analysis of the results both type of the instruments agreed with each other in Shepelevo reasonably well, but not in St. Petersburg. The reason why discrepancies occurred in St. Petersburg may be the higher PM concentrations in St. Petersburg than in Shepelevo and the fact that the sample flow rate of Derenda APM-2 was changed to considerably lower during the measurement campaign in St. Petersburg. It is clear that the lower sampling flow rate allows larger particles to penetrate the sampling inlet and therefore the mass concentration should be higher. However the comparison was not long enough to have quantitative results on the overestimation of the PM concentration. Further tests to demonstrate the influence of the sampling flow rate on the mass concentration was left to the MINERAL.

The Second Ozone comparison

Ozone comparison measurement campaign was conducted at the air quality (AQ) measurement station in Kumpula (SMEAR III station www.atm.helsinki.fi/SMEAR) in the city of Helsinki between 18 October 2010 and 14 January 2011. The AQ measurement station of Kumpula is located in the vicinity of the main building of the Finnish Meteorological Institute (FMI) surrounded by the campus area of the University of Helsinki and a residential area. The station is classified as an urban background station according to the Air Quality Directive (EC, 2008).

The aim of the ozone comparison was to demonstrate the calibration and measurement capability as well as the capability to correct the measured data on the basis of the calibration data. Both parties, the State Company Mineral (MINERAL) and the Finnish Meteorological Institute (FMI) used their own analyzers. Data acquisition system, QA/QC procedures and calibrations conducted by partners is described in the protocol prepared for the comparison.

The comparison was conducted as parallel measurements of the ozone analyzers of both parties using individual sample lines from the common sample inlet protected against rain and snow. FMI carried out practical arrangements at the station and looked after the measurements during comparison campaign.

Both of the analyzers were calibrated against the Finnish primary standard photometer, SRP-37, before and after the comparison campaign. FMI corrected the raw measurement data of both analyzers according to the calibrations performed at FMI before and after the measurement period. The initial calibration of the Mineral analyzer was, however, omitted by Mineral experts because of the malfunction of their ozone calibrator. Thus the analyzer was calibrated by Mineral in St. Petersburg after the campaign in January 2011 against their ozone generator GS-024-01, whose traceability goes to the Russian Standard Reference Photometer SRP-38 at the D.I. Mendeleyev Scientific and Research Institute for Metrology (VNIIM) in St. Petersburg. Mineral sent their calibration results and corrected comparison data to FMI.

In this comparison the overall agreement between the comparisons results of the Mineral and the FMI was very good. There was a difference of 5% between the calibrations performed by both parties to their own analyzers. When corrections of the measured data were based on the calibrations conducted at the FMI, there was practically no difference.

In conclusion, this comparison measurement proved to be an important tool to demonstrate the quality system and the measurement and calibration capability.

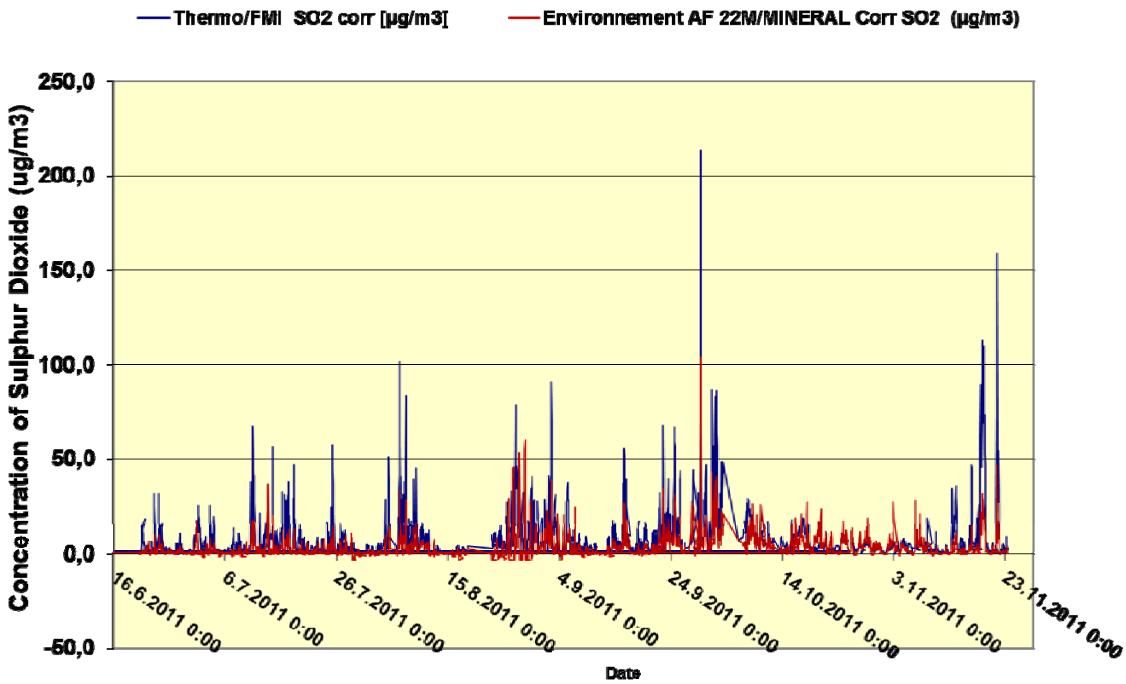
The Second NO_x and SO_2 comparison

The purpose of the campaign was to compare the measurement and calibration capability of nitrogen monoxide, nitrogen dioxide and sulphur dioxide measurements in St. Petersburg. The location of the station for the comparison experiment was selected near harbour area in Vasilyevskiy Island. Location of the station was selected in view to be able to measure the ship emissions. The station used for the experiment was a mobile station owned by State Company Mineral (MINERAL). The campaign started 16 June 2011 and ended 29 November 2011.

The analyzers used during the comparison campaign were owned by the State Company Mineral. It was the responsibility of MINERAL to carry out practical arrangements and surveillance of the analyzers during comparison campaign. Certified reference gases needed for the calibrations were also from MINERAL but were purchased from the Mendeleyev Scientific and Research Institute for Metrology (VNIIM). Therefore the traceability of the calibration gas was directly linked to SI unit. The data acquisition system by the State Company Mineral was used to collect the data from the analyzers. The data was sent by modem connection to the server at the MINERAL which collected the data from the station. After the data was collected into MINERAL it was also given to FMI

The calibrations of the analyzers were conducted by gas dilutors of both parties. The gas dilutors were capable of preparing the gas mixtures for calibration purposes. In addition the dilutor of FMI was also equipped with the option for gas phase titration to define the converter efficiency of the NO2 converter in the NOx analyzer. Before the comparison campaign in St. Petersburg the dilution device of FMI was calibrated against primary flow calibrator of FMI which is traceable to The Centre for Metrology and Accreditation (MIKES). There were three calibrations made by FMI during the comparison. MINERAL calibrated their analyzers once a month. The calibrations of MINERAL were normally made with zero and two calibration concentrations. Analyzers were also adjusted during the calibrations and no corrections to the measured values of the analyzers were made afterwards.

Results of the NO and NO2 measurements were rather good but the agreement between the SO2 results of MINERAL and FMI were not satisfactory because of the unstable behavior of the SO2-analyzer. In figures 5.2 the corrected hourly values of SO2 and NO2 concentrations for FMI and MINERAL are shown. From the figures one can see that no exeedence of limit value for both of the SO2 or NO2 occurred during the comparison.



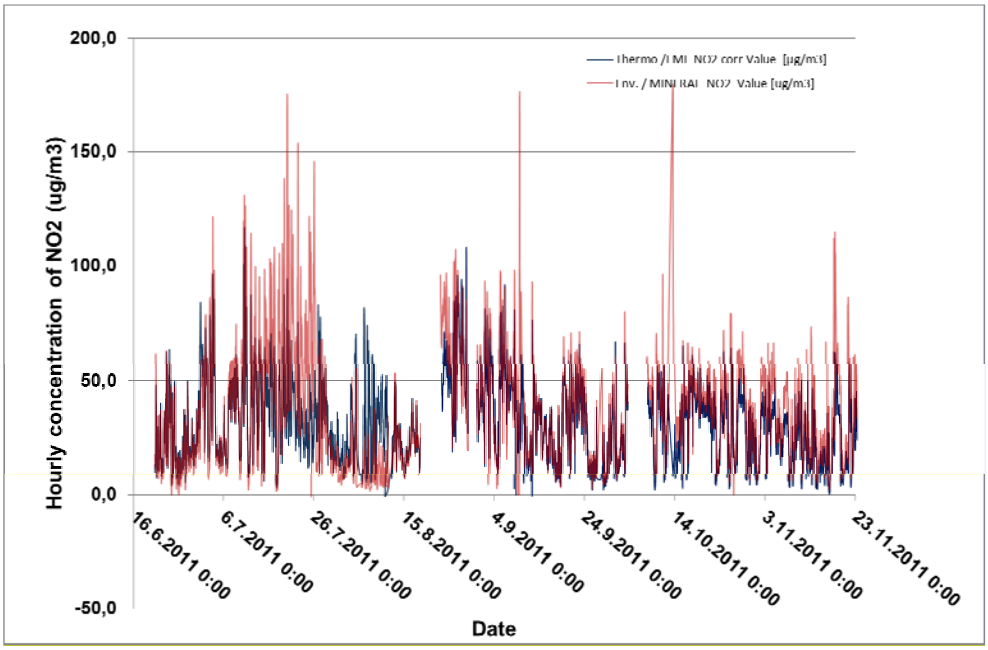


Figure 5.2 Corrected hourly values of SO2 from the second comparison exercise in St. Petersburg (above) and Corrected hourly values of NO2 from the second comparison exercise in St. Petersburg (below).

Lessons Learnt

At the beginning of the project the QA/QC procedures conducted in St. Petersburg were different in both countries. During the project the QA/QC procedure followed at the FMI was trained to field technicians of MINERAL. FMI prepared a guide for QA/QC procedures according to EU practices to be conducted to the measurement system at the air quality monitoring station. After the first comparison the calibration practices were improved by MINERAL. This was demonstrated during the second comparison study for SO2 and NOx comparison where the calibration concentrations were overlapping each other's. However discrepancies between the results of both partners occurred during the comparison. The cause for these remained unclear but there were also periods where the results were very good.

Results from particulate concentrations were good from Shepelevo but not as good from St. Petersburg. As was explained above the most evident reason for larger deviations of the comparison results in St. Petersburg was the change of sampling flow rate which collected larger particles than the cut off size of the used inlet.

Comparison experiments are good tool to demonstrate the functioning of the quality system. In overall we learned the level of the pollutants in some areas in the city of St. Petersburg and outside the city. Improvements on the calibration practices, building of the calibration laboratory in the premises of MINERAL and adapting the QA/QC procedures into the field measurements were harmonized towards the practices followed in Member state in Europe but are not exactly identical.

6.3 Calibration of Instruments

It is important in a network having many measurement sites that all the measurement results are accurate and comparable to each other. In order to achieve this, the calibrations of the instruments need to be conducted with the recognized standards. The recognized standard can be either a national standard which is linked to SI (International Systems of Units) unit directly or through a primary method of a measurement (PMM), or it can be internationally accepted standard or certified material (e.g. gas standard in a metal cylinder). Calibration of the instruments at the air quality monitoring network with the standards that are traceable to national standards is important for achieving the accuracy and the comparability of a measurement result within the stated uncertainty.

It should be emphasized that calibrations, and other quality assurance (QA) and quality control (QC) procedures are always made in a systematic, preplanned way. Based on the EU air quality directive (EC 2008/50) all the measurement results shall be traceable to national standards taken care of by National Metrology Institute (NMI) or by Designated Institute (DI). It is the responsibility of the National Reference Laboratory (NRL) in a Member State (MS) to be responsible for the quality of the measurement results. In addition to demonstrate the comparability of the air quality measurement results at European level, the NRLs are participating inter-laboratory exercise organized by the EC/Joint Research Centre.

The State Company Mineral (MINERAL) is responsible for maintaining the air quality network in St. Petersburg composing of more than 20 stations. The

MINERAL has a calibration laboratory to calibrate, test and do the maintenance of the automated analyzers and the mobile laboratory (calibration van) to conduct these procedures at the measurement sites. Calibration of the gas analyzers is made with zero and three different calibration concentration covering the measurement range evenly at all stations. Only the calibration frequency may change depending on the location. Calibration of the analyzer is performed by using the dynamic dilution method with a high concentration of gas standard and a zero air generator. The gas standards used by MINERAL are traceable to the All-Russia D.I.Mendeleyev Scientific and Research Institute for Metrology (VNIIM). Not only the gas standards but also the gas dilutors, ozone generators and flow measurement instruments are traceable to VNIIM. In addition, all types (model) of analyzers are tested and need to be approved by VNIIM before using them at the field. This practice seems to be well organized and functional. In table 9 the calibration frequency for the gas dilution system is presented.

The calibration procedure followed by MINERAL is as follows: inject zero air and three calibration concentration for a time period of 20 to 30 min in order to achieve stable reading of the analyzer. If the respond of the analyzer has been drifted for more than 5 % from the calibration concentration, the adjustment of the analyzer takes place. The adjustment of the analyzer takes place, however, after the first calibration is performed. The adjustment of the analyzer is made by changing the calibration coefficient in the analyzer. After adjustment calibration is repeated in order to see the success of the adjustment. The QA/QC procedure with their frequency is presented in chapter 4.5 (Quality assurance).

The process of calibration of the analyzer is acceptable: the important point in calibration of the site analyzer is to perform the calibration at the condition as the analyzer has been running (initial calibration). This gives the operator a change to see the deviations (drift) from the calibration concentration. The next thing is to perform the maintenance procedures e.g. record the diagnostic information of the analyzer, change the particulate filters in the sampling line and other maintenance and cleaning procedures of the sampling system. The adjustment of the analyzer takes place in order to fix the respond of the analyzer with the calibration concentration. Once this is achieved the operator makes the final calibration in order to demonstrate that the respond of the analyzer is in line with the calibration concentration. No mathematical correction is made in order to remove the possible bias due to the not ideal adjustment process.

As it is required, the measurement results without any correction need to be within 5 % from the correct values. However, there is no clear procedure to follow if the respond of the initial calibration fulfills this criterion. It is also important to be consistent with the unit, i.e. are the concentration of the measured pollutants expressed as mass concentration (µg/m3) or by mixing ratio by volume. The mass concentration is used at the air quality network in St. Petersburg and the temperature at which the concentration is expressed is 20 °C.

In the relevant EN-standards (EN 14211, 14212, 14625 and 14626) to measure the concentration of NO-NO2, SO_2, O_3 and CO in ambient air, the standards recommend to correct the analyzers based on the calibration by mathematical correction (linear function). Adjustment of the analyzer takes place only if the deviation of the calibration concentration is more than 5 % at the concentration of 80 % of the measurement range. The calibration of the field instruments needs to perform prior and after any maintenance or adjustment of the analyzer. This practice is the same as being conducted by MINERAL.

In case of particulate matter the reference method defined by EU is the gravimetric method (EN 12341 and EN 14709). The method is equipped with an inlet which is aerodynamically size selective for $PM_{2.5}$ and for PM_{10} at a flow rate of 2.3 m^3/h (i.e. a low volume sampler) and a filter sampling. The procedure for conditioning and weighing the filters at standard condition is well described in the standards. The member state can use the reference method or any other method which it can prove to provide equivalent measurement results as the reference method. The guidance for testing the candidate method against the reference method has been prepared (Guide to demonstration of equivalency, 2010). It is important to follow the instruction and maintenance procedures of the standard in order to guarantee that the method meet its specifications. The sample flow rate needs to measure at regular intervals, as well as to calibrate the temperature probe in the sampling system. In addition cleaning of the sample inlet and creasing of the impaction plate of the inlet after cleaning need to be performed at regular time intervals as required by the standard.

The MINERAL used the reference method applied in the continuous PM analyzer by Derenda , Germany. The analyzer measures the concentration of the particulate matter based on the optical method which can be calibrated based on the filter sampling i.e. following the reference method. However the MINERAL use only the optical part of the Derenda instrument leaving the reference method out.

Table 9. The calibration frequency for the gas dilution system.

Calibration, checks and mainte-nance	**Frequency**	**Action criteria**
Calibration of the gas dilutor TEI 146C - Flow rate (span and dilution flow) - UV lamp (ozone source) Maintenance of the gas dilutor TEI 146C - details, see manual	Once a year Once a year (if used for ozone measurements) Once a year	> 5 % flow rate
Gas standards - Purchase or recertification of the gas standards Pressure regulators - change of gasket	Every two years Every two years or changing the	Cylinder pressure < 10

Calibration, checks and maintenance	Frequency	Action criteria
- check of leakage	gas cylinder Every time when the cylinder is used	bars

Also the sample flow rate has been changed from 2.3 m^3/h down to 1.5 m^3/h which may overestimate the mass concentration in the ambient air, since the lower sampling flow rate tend to increase the aerodynamic cut off size of the sampling inlet. The reason for changing the sample flow rate from the standard requirement to a lower sample flow rate was not understood.

Lesson Learnt

As a conclusion the calibrations of the instruments in the automatic air quality monitoring network in St. Petersburg are performed at acceptable level. The metrological institute, VNIIM, has a specific role to provide calibration and testing service of the equipment to the air quality network in St. Petersburg. The MINERAL has support from the calibration laboratory which is equipped for all types of calibration facilities that are needed to run the air quality measurement station. Besides the field equipment also the calibration facilities need calibration in order to maintain the traceability of the measurement results to SI unit. The only thing where the calibration was not complete was the measurement of the concentration of the particulate matter in the air.

6.4 Data Exchange

The exchange of background monitoring stations data was carried out in accordance with the "Memorandum on cooperation in exchanging atmospheric quality data obtained at background monitoring stations in Finland and St. Petersburg" as of March 18, 2009 in order:

- to analyze the atmospheric air quality;
- to forecast its condition;
- to estimate the emission amounts from various sources (at the cross-border transfer);
- to control the gaging equipment operation used in background monitoring stations;
- to carry out joint modeling and researches.

The Memorandum concluded by the Finnish Environmental Ministry and the Nature Management, Environmental Protection and Ecological Safety Committee has secured the arrangements concerning the atmospheric air quality data exchange between the background monitoring stations in real time operation mode and basic data exchange terms.

The partners monitoring the atmospheric air have been determined in the Memorandum. They are: the Meteorological Institute on the part of the Republic of Finland and the “Mineral” Specialized Company” State Unitary Geological Enterprise on the part of St. Petersburg. Also, the protocols of atmospheric air quality data exchange between the background monitoring stations in real time operation mode have been approved.

The data exchange program between the selected background monitoring stations is presented in the following tables:

Table 10. Background monitoring program for the period from May 2009 to July 2010 *

No.:	Name / address of the station (geographic coordinates)	Pollutants
1	House 1, The Golden Beach in Zelenogorsk, Town of Zelenogorsk, Saint-Petersburg, Russia (60 ° 11 '15.9 ", 29 ° 41' 42.3"),	nitric oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), PM_{10}
2	Shepelevo / St. Petersburg Hydrological Testing Area, Kandikyulya Settlement, Lomonosov District, Leningrad Region, Russia (59 ° 55 '35.9 ", 29 ° 38' 12.4")	nitric oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), PM10, $PM_{2,5}$
3	Virolahti / Löyhyntie 401, FI-49900 Virolahti, Finland (60° 31` 37.4", 27° 40` 32.8")	Nitric oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), PM_{10}, $PM_{2,5}$

*) Deadline of the third cooperation stage is February, 2010; deadline of finishing the Shepelevo monitoring station’s continuous work is July, 2010.

Table 11. Background monitoring program for the period from March 2011 to February 2012 *

No.:	Name / address of the station (geographic coordinates)	Pollutants
1	House 1, The Golden Beach in Zelenogorsk, Town of Zelenogorsk, Saint-Petersburg, Russia (60 ° 11 '15.9 ", 29 ° 41' 42.3"),	Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Ozone (O_3), PM_{10}, Meteorological parameters
2	Sestroretsk / Gorky Str., Town of Sestroretsk (Resort Area), St. Petersburg, Russia (60 ° 6 '38.4 ", 29 ° 57' 38.1")	Nitric oxide (NO), Nitrogen dioxide (NO_2), Ozone (O_3), $PM_{2,5}$
3	Kronenstadt / Town of Kronenstadt (the Kronenstadt District) St. Petersburg, Russia (59 ° 59 '11.2 ", 29 ° 47' 36.6")	Nitric oxide (NO), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), $PM_{2,5}$
4	Virolahti / Löyhyntie 401, FI-49900 Virolahti, Finland (60° 31` 37.4", 27° 40` 32.8")	Nitric oxide (NO), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Ozone (O_3), PM_{10}, $PM_{2,5}$, Meteorological parameters
5	Utö / Isle of Utö at the Baltic sea, Finland (N 59.77923 E 21.37395)	Nitric oxide (NO), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Ozone (O_3), $PM_{2,5}$, Meteorological parameters
6	Luuki / Luukinranta, Espoo, Finland (N 60.31349 E 24.68937)	Nitric oxide (NO), Nitrogen dioxide (NO_2), Sulfur dioxide (SO_2), Ozone (O_3), PM_{10}, $PM_{2,5}$, Meteorological parameters

*) The 4th cooperation period deadline.

The data obtained from the stations were regularly presented (without exceeding the 12-hour delay) on the ftp-server of the Finnish Meteorological Institute and the Mineral Company. The partners participating in the information exchange had an access to information in the other Party's server.

Among other project activities on-line data exchange of gaseous pollutants and PM measurements reached the high level when the Memorandum of Understanding (MoU) between the Committee of St. Petersburg and the Ministry of Environment of Finland was signed. Under this MoU the on-line data exchange agreement between the State Company Mineral (MINERAL) and the Finnish Meteorological Institute (FMI) was signed at first time in 2009 and was prolonged in 2010.

The stations that were included at the first place to the on-line data exchange agreement between the State Company Mineral and the Finnish Meteorological Institute belong to the air quality network of St. Petersburg run by the State Company Mineral and to the background air quality network of Finland run by the Finnish Meteorological Institute. It was agreed that the measurements were conducted according to the best practice by both countries following the guides and legislation by European Commission and by Russian Federal legislation. The comparison period consist from the beginning of June 2009 to the end of May in 2010. The atmospheric pollutants that were considered were nitrogen monoxide (NO), nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide (SO_2) and particulate matter of the size class of less than 10 µm (PM_{10}) and 2.5 µm ($PM_{2.5}$). The background stations of the air quality network in St. Petersburg as well as the background station of Virolahti are shown in Figures 6 and 7.

Background air quality data describes more generally the influence of the long range transport of pollutants. The daily mean variation of NO, NO_2, SO_2, O_3, PM10 and $PM_{2.5}$ concentrations shows general features how concentrations are changing daily , monthly and annually. Especially diurnal variation of O3 is evident due to the behavior of the boundary layer while in case of NO, NO_2 and SO_2 the diurnal variation is mostly indication of the emission from local source. However, if local source is not evident the concentration of NO_2 describes the long range transport. In general the SO_2 concentrations are very low nowadays due to the reduction agreement of sulphur dioxide. Similarly the diurnal variation of the PM_{10} concentration describes the emission from local sources while in case of $PM_{2.5}$ the concentration is more evenly distributed and describes the long range transportation rather than emissions from local sources.

The monthly means of NO, NO_2, SO_2, O_3, PM_{10} and $PM_{2.5}$ concentrations shows seasonal behavior for each of the component at Shepelevo, Zelenogorsk and Virolahti. The results from station Zelenogorsk deviates clearly from the two other stations with respect of the gas compounds and PM10. The station Zelenogorsk is influenced by the local sources and traffic as was pointed out in the audit report (Kuronen and Leppänen 2009).

The data capture from June 2009 to May 2010 was > 90 % in Virolahti for all components. At Shepelevo the data capture was between 57 % ($PM_{2.5}$) and > 90 % (ozone). At Zelenogorsk the data capture was less than 90 % for each of the measured pollutants. The data capture of > 90 % for continuous measurements is required by CAFE-directive.

It should also remarked that exceedance of the limit values occurred only once in daily PM10 concentration in Zelenogorsk. In case of any other of the measured pollutants no exceedances of the limit values occurred during the period June 2009 to May 2010 as defined by EU legislation. The annual average of $PM_{2.5}$ was 6.3 µg/m^3 and for PM_{10} it was 6.5 µg/m^3 in Shepelevo while in Virolahti it was 6.1 µg/m^3 and 9.5 µg/m^3, respectively.

As a conclusion the on-line data exchange agreement between the State Company Mineral and the Finnish Meteorological Institute has worked very well. At the first place the air quality measurements of NO, NO_2, SO_2, O_3, PM_{10} and $PM_{2.5}$ from background stations of Shepelevo, Zelenogorsk and Virolahti were included into the agreement. The data capture exceeds 90 % as required by CAFÉ-directive at Virolahti for all measurements as well as in case of ozone in Shepelevo, being lower with the other measurements in Shepelevo and in Zelenogorsk. Mostly the data capture was still more than 80 %. The concentration levels were very similar in Shepelevo and in Virolahti showing the level that is generally met at remote areas. The station of Zelenogorsk was located close to the areas where human activities caused emissions which were seen also on the concentration level. On the whole the on-line data exchange agreement worked very well between the two parties. It shows that the measurement capability is good on both sides and also that in Shepelevo and in Virolahti the results were very comparable for each of the measured pollutants.

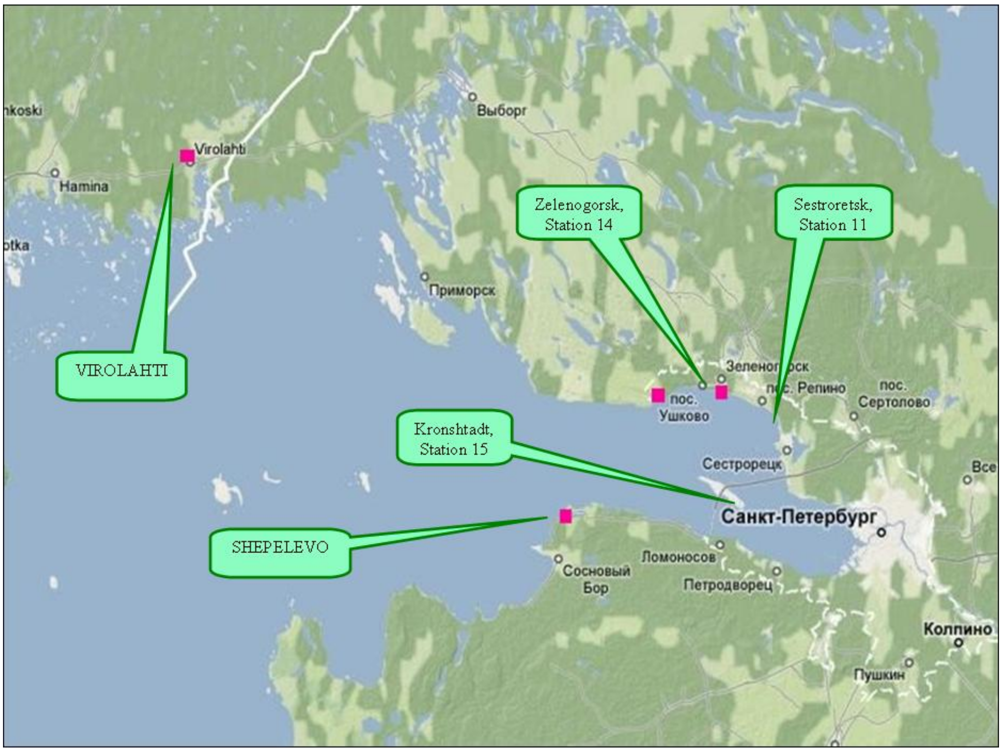


Figure 6. Locations of the background stations in the automatic air quality measurement network in St. Petersburg is shown together with the background station of Virolahti in the Finnish side.

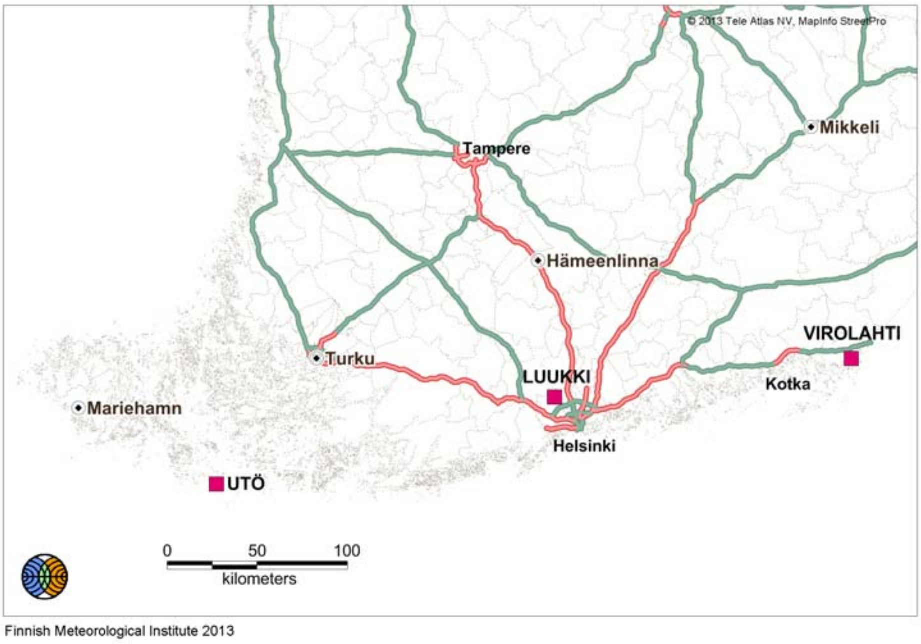


Figure 7. Locations of the background stations (Utö, Luukki and Virolahti) that are included in the online information exchange protocol from Finnish side.

Lessons Learnt

Initiating the online air quality data exchange between the St. Petersburg and Finland was first of its kind. The data can be used to study and forecast the long range transportation episodes and verification of the regional scale air quality models. Analysis and comparison of the data can be used to assess daily and weekly variation and examination of trajectories. There is a lot of interest towards the background air quality data for example in the international research projects. As the data policies of Finland and the city of St. Petersburg are different the usage of the online information exchange data needs to be separately agreed between the partners. The future of the online information exchange is unclear if the cooperation between the project partners do not officially continue. The data exchange and the extension of it have been included to the future cooperation proposals.

6.5 Air Monitoring Quality Assurance and Quality Control

The quality system (QS) set up the procedures and practices to control the quality of the measurement results. Quality assurance (QA) describes the systematic activities implemented in the quality system in order to guarantee that the requirements set for the activities e.g. data quality objectives, are fulfilled. Quality control (QC) is a process to demonstrate that the entity (laboratory) reach their quality as they claim. Based on the EU air quality directive (2008/50/EC), accreditation based on ISO 17025 is mandatory for the national bodies, more precisely the National Reference Laboratories (NRL), for the reference measurement methods. The reference methods are defined for those atmospheric pollutants where EU has set limit values i.e. the maximum concentration of pollutant in ambient air. The reference methods are described by standards prepared by European Standardization body (CEN). In the directive (2008/50/EC) all type of the analyzers that are applying the reference method need to be type approved by the accredited (ISO 17025:2005) testing laboratory and accepted by the national authorities or bodies.
During the course of the project FMI prepared a document which was intended to be used for QA/QC procedures at the automatic air quality network in St. Petersburg. In addition a system audit was conducted to two air quality background stations to check the QA/QC practices at the station. The guide for QA/QC procedures describes the necessary actions and they frequency that are required by the relevant EN standards at the field stations. The frequency of the actions may change depending on the classification of the station i.e. traffic station, industrial station, residential area and urban background station. In Table 1 the QA/QC procedures and their frequency are presented at traffic and industrial station. In Table 2 similar QA/QC procedures are presented for PM measurements. Few remarks on the actions in Table 1 are clarified. Calibration of the analyzer is described in more details in chapter 4.3 as well as the importance of the precalibration. The span gas source of the analyzer (permeation source) is normally used for span check of the analyzer. The purpose of this action is to check the output concentration (recertification) of the span gas source. In case if the span check is performed by gas cylinders the concentration of the gas cylinder should be certified every six month. Lack of fit means the deviation of the analyzer respond from the linear regression line when multipoint calibration is performed to the analyzer. The frequency of the linearity check is once a year according to EN standard, but

recommended here to perform during multipoint calibration. The reason for this is that the linearity is checked mathematically for which training has been given. The process is very quick to perform once the multipoint (3 to six points) calibration result exists. A check of efficiency of NO_2 converter is made twice a year according to the guidance of the QA/QC document. The SOP for performing the GPT was handed to MINERAL during the training on this topic, see chapter 4.7. The NO_2 results shall be corrected based on the converter efficiency in any case. It must be noted that the converter efficiency need to be better than 95 %. If it is less the converter should be changed.

In case of measurements of particle mass concentration in the air, the CEN has prepared technical specifications to be used with the automated PM analyzers (FprCEN/TS 16450, 2012). Table 2 consists of most of the recommended QA/QC procedures. However it was discovered during the PM comparison that the sampling flow rate was reduced considerably from the flow rate that is used by the EN standard (EN 12341 and EN 14907) for the EN sampling inlets for $PM_{2.5}$ and PM_{10}. Reduced flow rate tend to increase the cut of size of the particle size and overestimate the mass concentration.

Audit of the Air Quality Stations in Zelenogorsk and Sestroretsk

Audit of the air quality stations in Zelenogorsk and Sestroretsk in St. Petersburg was carried out on 16 February 2010. Audit was a part of the practical level cooperation on developing Quality Assurance/Quality Control (QA/QC) system of the AQ monitoring system in St. Petersburg.

The two stations represent background stations for the network of air quality stations in St. Petersburg with ca. 20 stations. They are both located northwest of central St. Petersburg on the sea shore of the Gulf of Finland. The State Company Mineral is responsible for running the network.

The scope of this audit was the whole measurement system in general, which is called system audit. During the audit procedure the entire system from the air inlet to the data processing and the quality assurance was reviewed.

In the site descriptions it would be useful to have more detailed information on emission sources, for instance number of inhabitants near the stations, number of inhabitants in major source cities (St. Petersburg), traffic amounts on the nearby roads etc. The vicinity of the town of Zelenogorsk with a lot of construction activities still increasing the amount of population, especially in summer time, may have a local influence on the concentrations at the Zelenogorsk station.

The measurement cabins were small, but very clean and everything was in good order with no extra stuff around. The layout of the instruments was well done. The requirements for the maintenance and calibration of the analyzers were well documented. However, there should be written schedules for maintenance and calibrations, plan for training of personnel and detailed instructions for using the analyzers. In the logbook all the actions and tasks done at the station should be recorded in detail. The calibrations are done once per month in the laboratory and zero and span checks two times per month at the station. It would be preferable to do the calibrations at the station using transfer standards and field calibrators. In the laboratory there should be a data acquisition system for collecting the measured minute values during the calibrations.

Table 12: QA/QC procedures and their frequency for the ambient air measurements for carbon monoxide, sulphur dioxide, total reduced sulphur compounds and for oxides of nitrogen for urban stations.

Calibration, checks and maintenance	**Frequency**	**Action criteria**
Calibration of the analyzers - multipoint calibration - precalibration	Every month and after repair Every month	
Recertification of span gas source of the analyser	Two times a year	Zero: ≥ detection limit Span: ≥ 5,0 % from last certified value
Zero and span check	Once a day or at least every two weeks	Zero: ≥ 5 nmol/mol Span: ≥ 5,0 % of initial span value
Lack of fit (multipoint calibration in laboratory or in field)	Check should be performed during each calibration	Lack of fit > 6,0 % of the measured value
Converter efficiency NO_2 converter	Two times a year (GPT)	eff ≤ 95 %

Calibration, checks and maintenance	**Frequency**	**Action criteria**
Test of the sample manifold - Operation of the fan of the manifold - Cleaning of the manifold - Changing of the sample tube	At two weeks intervals Two times a year Two times a year	Fan is not working Dust or dirt inside the manifold Tubes are dirty inside
Change of particulate filters at the analyzer inlet	At least every two months	Response to span gas passing the filter is ≤ 97 %
Maintenance of the analyzer	As required by manufacturer	As required

Table 13: QA/QC procedures and their frequency for the particulate measurements for continuous $PM_{2.5}$ and PM_{10}.

Calibration, checks and maintenance	**Frequency**	**Action criteria**
Calibration of the PM analyzer - Mass - Flow rate - Temperature and pressure sensor Calibration of PM sampler - Flow rate	Every three months and after repair Once a year Once a year Once a year	

Calibration, checks and maintenance	Frequency	Action criteria
Sample manifold - Cleaning of the manifold	At least two times a year	
Maintenance of the analyzer - PM analyzer and PM sampler	As required by manufacturer	As required

Lessons Learnt

The requirements presented in the QA/QC report by Waldén et al. were not totally followed, for instance in calibrations. The next QA/QC plan and the SOPs should be written so that the everyday working methods are in coincidence with them.

The traceability of the measurements leads to the D.I. Mendeleyev Scientific and Research Institute for Metrology (VNIIM) through the reference standards used for the calibrations and measurements. The traceability of the ozone analyzers goes to the standard reference photometer (SRP-38) at VNIIM.

As a conclusion the recommended QA/QC procedures and their frequencies at the field stations in St. Petersburg follows the practices of the accredited calibration laboratory of the FMI and the practices that are used by the NRL of the member state and at air quality networks across Europe. It is a task of MINERAL to follow up the QA/QC procedures as recommended and to make changes accordingly. The system audit conducted at the air quality stations in Zelenogorsk and Sestroretsk showed good practices and that QA/QC procedures are followed in most part at the stations. Some findings were made to improve the activities.

6.6 VOC Sampling and Comparison of Methods

The co-operation in the field of volatile organic compound (VOC) analysis began by implementing the diffusive sampling of VOCs to St Petersburg. The samples were analyzed with a gas-chromatograph equipped with a flame ionization detector (FID) in the VNIIM laboratory. Diffusive sampling method is based on the standards SFS-EN ISO 16017-2:2003 and SFS-EN 14662-4:2005. Diffusive sampling is an inexpensive and simple way of measuring aromatic VOC compounds in urban air. Of aromatic VOCs benzene, in particular, has been shown to be an important carcinogen in studies of human health and European Union directive (2008/50/EC) sets the annual mean limit value at 5 µg m-3 for benzene. The directive also sets the upper (3.5 µg m-3) and lower (2 µg m-3) assessment thresholds for benzene mean annual concentrations.

During the course of a project, the parallel sampling exercise that lasted 8 months was arranged in St Petersburg and results agreed considerably well between VNIIM and FMI laboratories (Table 14). However, the exercise revealed several issues that could be improved in the VOC sampling and analysis. These include a use of commercially packed sampling tubes, regular use of standard reference materials and the use of mass-selective detector in the analysis.

Table 14: The mean concentrations (ng m^{-3}) for the period 11.10 2006-22.6 2007 of aromatic hydrocarbons at St Petersburg air quality stations 4 and 9 measured at the FMI and VNIIM laboratories.

	station 4 average VNIIM	station 4 average FMI	station 4 VNIIM/FMI	station 9 average VNIIM	station 9 average FMI	station 9 VNIIM/FMI
Benzene	2850	2800	1.02	2322	2158	1.08
Toluene	9689	10541	0.92	8010	8310	0.96
Ethylbenzene	1838	2046	0.90	1347	1514	0.89
p/m-Xylene	4721	6527	0.72	4011	4897	0.82
o-Xylene	2733	2953	0.93	2265	2139	1.06
Styrene		377			260	
Propylbenzene		778			544	
3-Ethyltoluene		2097			1412	
4-Ethyltoluene		1065			726	
2-Ethyltoluene		857			596	

The exercise also showed that the 8-month benzene mean concentrations (2.8 µg m^{-3} at station 4 and 2.3 µg m^{-3} at station 9) exceeded the lower assessment threshold at both stations. Due to fairly high benzene concentrations in St Petersburg Mineral decided to change to pumped sampling of VOCs instead of diffusive sampling. The pumped sampling is considered to be more reliable than diffusive sampling, also in the directive 2008/50/EC diffusive sampling is considered as an indicative method and it can be used only if the annual mean concentrations are below upper assessment threshold (3.5 µg m^{-3}). In case upper assessment threshold is exceeded, fixed measurements shall be used to assess the ambient air quality. In the case of benzene fixed measurements mean pumped sampling or monitors instead of diffusive sampling.

Figure 8. Air Quality Station 4 in St. Petersburg where aromatic hydrocarbons were measured

When using long-term pumped sampling, stronger adsorbent have to be used than Carbopack-B, which was used for diffusive sampling. During the project, we tested if Carbopack-X would be suitable for VOC long-term low volume pumped sampling.

Table 15 shows the average concentrations of studied compounds in both samples. Difference between the samples was within the uncertainty limits only for ethylbenzene. For benzene and toluene pumped sampling gave higher results than diffusive sampling, but the test does not show which one is more correct. For larger compounds pumped sampling onto strong adsorbent is not suitable. It is likely that desorption efficiency from Carbopack X tubes is poor for these compounds and the collected compounds are retained in the adsorbent. No breakthrough was detected from the Carbopack X tubes during two weeks of pumping with the flows of about10 ml min^{-1}.

Figure 9. Sampling equipment used in VOC sampling

Table 15. Concentrations (ng m^{-3}) of aromatic hydrocarbons in diffusive and low flow samples collected in Helsinki in April 2011 and the difference between them.

ng m^{-3}	Diffusive	Low-flow	Diffusive/ low flow
Benzene	398	556	72%
Toluene	626	846	74%
Ethylbenzene	172	174	99%
p/m-xylene	513	346	148%
o-xylene	169	104	163%
Propylbenzene	24	5	430%
2-Ethyltoluene	18	6	300%
3-Ethyltoluene	47	16	304%
4-Ethyltoluene	8	<LOQ	320%

At the end of the project Mineral ordered pumped sampling devices that collect VOCs with low sampling volumes for several days or weeks. These devices seemed to fit well for the Mineral purposes to measure benzene in several locations, but not with too many samples to analyze. However, these sampling devices should be thoroughly validated.

Lessons Learnt

As VOC measurements were conducted in St Petersburg, we learned to know the VOC concentrations in St Petersburg area. The VOC measurement method development started with diffusive sampling method commonly used in Finland, but since the concentrations were higher than in Finland pumped sampling had to be applied instead. The sampling device purchased by Mineral for long-term pumped sampling seemed suitable, but during the project it was not yet validated. Long-term pumped sampling was a new sampling technique for us. The personnel at Mineral seemed very motivated to conduct VOC sampling according to EU legislation. The VOC analysis was conducted at the VNIIM laboratory. Validation of the sampling and analytical methods and daily operation may not be the best possible, when sampling and analysis are divided between two institutes.

6.7 Trainings

One of the very practical ways of co-operation with the MINERAL during the project was training. The personnel of the FMI conducted training for various topics associated with the operation and calibration of the analyzers, defining the converter efficiency of NO-NOx analyzer, correcting the measurement results at the station and at the laboratory based on the calibration results, quality system and QA/QC procedures and uncertainty estimation of the measurement results. Most of the training was given in view of the EU directives and practices required by the EN standards. Trainings were given on theoretical base (lecturers), hands on training and following the practices at the MINERAL laboratory. Training was arranged at the FMI facilities e.g. in the calibration laboratory but also at the calibration laboratory at MINERAL. The training periods lasted for one day up to one week training for technicians as well as for persons involved with data analysis.

During the “Hands on training” events at the FMI calibration laboratory the calibration procedure of the FMI was shown step by step to the technician from the MINERAL. Similar training was conducted for checking the diagnostic information of the analyzers, recalibration of the gas cylinder and a transfer calibrator and calculation of the calibration results. At the end of the training the Standard Operating Procedures (SOP) for running different type of analyzers and calibration instruments at the laboratory and at the field, gas phase titration method to define the converter efficiency, calculation and correcting the results based on the calibration results were handed to technician. With these instructions the MINERAL can follow the procedures of the accredited calibration laboratory as well as the procedures that are used across Europe.

The training event for estimation of measurement uncertainty was another good example where the practice of an accredited calibration laboratory and the European practices were trained to the personnel of the MINERAL. Although the concept of the uncertainty is difficult to adapt during a three day course the basics of the uncertainty calculation was given. Most of the time was, however, devoted to the calculations of the uncertainty of the SO_2, NO-NO_x, CO and O_3 measurement results and the uncertainty of the calibration methods used by MINERAL. At the end of the training a complete uncertainty budgets for the measurement results obtained at the measurement station at St. Petersburg were prepared for the gaseous compounds. Additionally, also the uncertainty of the concentrations of gas mixtures prepared by dynamic method was prepared for gas compounds used by MINERAL. All the results and software for uncertainty calculations were handed to the personnel from MINERAL.

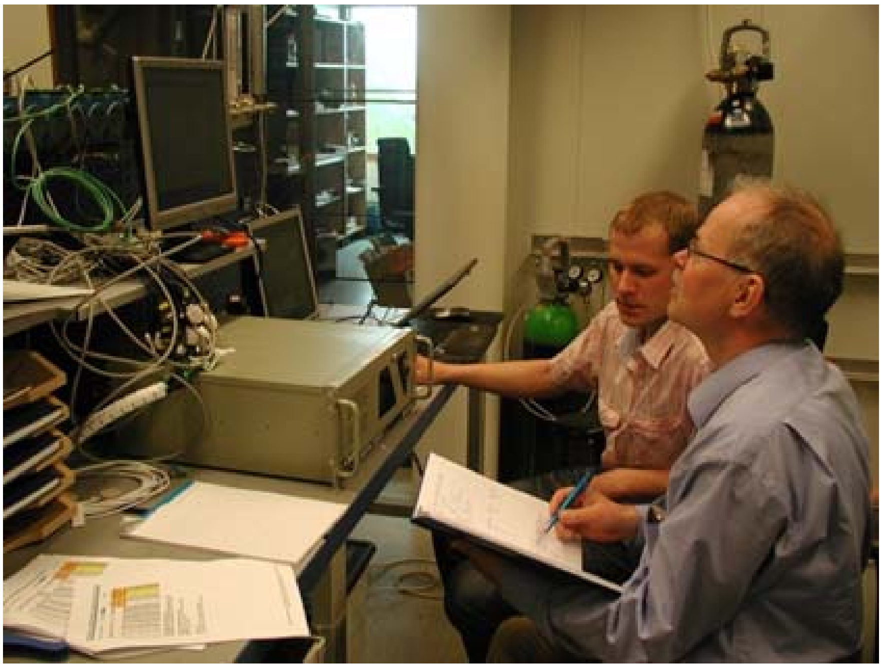


Figure 10. Hands on training in process. Mineral staff getting familiarized with FMI calibration laboratory.

Lessons Learnt

Hands on training are a fruitful way of educating personnel, especially when both parties (FMI and MINERAL) are experts on the field. The SOPs are valuable tools to adapt and follow the technical procedures in a harmonized way in the laboratory and at the field operations. The concept of uncertainty may be a difficult topic but with examples for practical application the uncertainty budgets for the measurement results of gaseous compounds can be very understandable. With the software for uncertainty calculations the personnel from the MINERAL can calculate the uncertainty of the measurement results at different concentrations, e.g. at the limit values of the federation of Russia as well as in cases where new instruments or gas cylinders are purchased.

7 AIR QUALITY ASESSMENTS BY DISPERSION MODELING

7.1 Models used in St. Petersburg and Finland

Models used in St. Petersburg

As part of the project, the estimates for dispersal of pollutants in the atmospheric air were performed using a programme complex «Ecology-City-St. Petersburg », with the use of a Russian method OND-86 "Methods for calculation of concentrations of harmful substances in the atmospheric air, contained in the emissions of enterprises". The method is intended for calculation of utmost one-time concentrations in the atmospheric air from the source (sources) of pollutant emission and allows for meteorological parameters influencing the dispersal of harmful substances in the atmosphere. The extent of precision of the method meets the requirements developed by the European Union. OND-86 technique makes it possible to effect calculations for atmospheric pollutants concentrations for any point in the area around the source (sources) of emissions.

From 2003, as commissioned by the Committee, the work was implemented for adaptation of the programme complex «Ecology-City-St. Petersburg», based on the OND-86 method, as concerns calculations for dispersal of pollutants from numerous sources of emissions in the atmospheric air. As a result, within three years, a modular programme complex «Ecology-City-St. Petersburg» was developed and implemented, which includes modules for calculation of utmost one-time concentrations relating to the 20-30-minute averaging interval in adverse meteorological conditions, and a module to estimate the average-year surface concentrations. Surface concentration of a harmful substance means concentration of a substance at the height 2 m above the ground.

In the programme complex «Ecology-City-St. Petersburg», the source data for the calculations are contained in the database for sources of atmospheric-air emission and in the files of meteorological parameters. The calculations for dispersal of pollutants in the atmospheric air are made on the basis of information about the parameters of industrial emissions sources (stationary sources) and transport (movable sources). Stationary sources are divided into organized (point, linear) and unorganized sources (ground). The organized source of atmospheric pollution is a device for directional lead-out of pollutants in the atmosphere (smoke stack, air well, ventilation skylight). The unorganized source of atmospheric pollution does not have any special device to conduct the pollutants in the atmosphere (car park, forklifts area, welding area, etc.). For stationary sources, the database is formed by results of emissions inventory, made by an organization for obtaining permission for discharge.

Movable sources of emissions are motor transport and water transport. Emissions from motor transport sources are taken into account as discharge from the motorway sections representing polygonal objects. The volume of emission depends on the structure of traffic flow (speed, intensity, kinds of transport), with assessment made by visual control and on the basis of automated sensors. On 01.01.2012 the database for movable sources making emissions in the atmospheric air contains information about 1537 highway sections used to estimate dispersal from motor transport, and 379 polygonal objects in the basin of the Big Port of St. Petersburg used to estimate dispersal from sea transport.

To make calculations of utmost one-time concentrations and average annual surface concentrations in the atmospheric air from the source (sources) of discharge of pollutants, the following background information is used:

Information on the sources of discharge:

- Source type - point, linear, or ground (unorganized).
- Height of the source above the ground level, m.
- Diameter of the source mouth, m (for point sources).
- Temperature of discharged air-gas mixture, °C.
- Rate of emission of air-gas mixture, m/s (for point and linear source).
- Consumption of air-gas mixture, m3/s (point and linear source 1).
- Emission of a pollutant, g/s (for each substance in calculation of utmost one-time concentrations).
- Yearly emission of a pollutant, t/y (for each substance in the calculation of average yearly surface concentrations).
- Coordinates of the source.

The meteorological parameters files with the original meteorological information contain standard terms for St. Petersburg, including:

- Coefficient depending on temperature stratification of the atmosphere.
- Average air temperature of the hottest and coldest months, °C.
- Wind speed exceeded in the given locality in the long-term average in 5% of cases.

In calculating the average concentrations, meteorological parameters files are used with the original meteorological data and climatic characteristics of the city, that contain data on the average temperature of the territory, average precipitation rate, washout ratio and other coefficients and parameters necessary for calculation of average yearly concentrations. The characteristics are determined by results of observations over a 10-year period.

The result of calculation is an analytical grid with a mesh size set by the operator. The report file contains a two-dimensional picture (in format dbf), where the fields are coordinates of design points and concentration of the pollutant in a given point, presented as absolute value and the value linked to the maximum permissible concentration of the substance.

Models used in Finnish Meteorological Institute

Finnish Meteorological Institute has over 40 years' experience on the dispersion model development and the use dispersion models in various applications. FMI has expertise in the atmospheric and dispersion models for different scales; from micro scale up to the global scale. In this project only the local scale dispersion modeling tools have been used, thus other modeling tools have been left out from this report. FMI has developed local scale Gaussian dispersion modeling tools for different applications;

- UDM – FMI is model for points or area sources;
- CAR – FMI is model for the traffic emissions
- ODO – FMI is model for the odorous compounds
- ESCAPE – FMI is model for accidental releases
- EXPAND is model for exposure assessment
- STEAM is emission model for ship emissions based on the AIS location system

The dispersion modeling calculations for city planning or environmental impact assessment are usually carried out by using UDM-FMI and CAR-FMI models. These local scale air pollution dispersion models have been developed to be used for assessing the dispersion of atmospheric emission sources. From preceding dispersion models UDM-FMI model is commonly used for the stationary emission sources and CAR-FMI model for moving emission sources vehicles or ships in roads or routes. These two modeling tools are also used in the AQM project's joint modeling activities. More detailed information about FMI's dispersion models (http://pandora.meng.auth.gr/mds/showlong.php?id=121&MTG_Session=785c7232fa7d66cd5e1686081aa37682)

Description of Models and meteorological data

FMI's models used for dispersion modelling were local scale Gaussian plume model UDM-FMI (urban dispersion model) and the open area line source model CAR-FMI (traffic model). UDM-FMI dispersion model is an integrated urban scale model, taking into account source categories like point, area and volume sources. In this study the urban model was used for power plants and industry emission (point sources). It includes a treatment of chemical transformation (for NO_2) and deposition (wet deposition, and dry deposition for SO_2 and NO_2), plume rise, downwash phenomena and dispersion of inert particles. The model allows also for the influence of a finite mixing height. The dispersion module of the system utilises input emission data, pre-processed meteorological data and geographical data. The dispersion module computes hourly time series of the concentrations of pollutants.

FMI model used for dispersion modelling the emissions of vehicles and ships in roads or routes was the open area line source model CAR-FMI (traffic model). The CAR-FMI is a Gaussian finite line source dispersion model designed to be used in an environment, in which there are not too many buildings or obstacles. In the model, roads are treated as straight segments. The properties of traffic and emissions, as well as meteorological variables, are assumed to be constant during each hour. Model allows for a network of finite line source emissions of inert (CO, NO_x) and reactive (NO, NO_2, O_3) gases and exhausted fine particulate matter ($PM_{2,5}$). It includes an analytical solution for the chemical cycle NO-O_3-NO_2. The Gaussian dispersion parameters are functions of boundary layer variables, and their dependence on source height is also accounted. The chemical transformation of nitrogen oxides is modelled by using the so-called receptor-oriented discrete parcel method. This model includes the basic reactions of nitrogen oxides, oxygen and ozone, but the influence of hydrocarbons is neglected.

The chemical transformation for NO oxidation to NO_2 is taken into account in the model to evaluate the actual NO_2-concentrations in ambient air. In the model calculations it is also needed the proportion of nitrogen dioxide (NO_2) in exhaust cases. In the ambient air the percentage of NO_2 starts to increase through oxidation of NO mainly by atmospheric ozone (O_3).

The dispersion models used here are based on the steady-state hypothesis, where emission rates and meteorological conditions are assumed to remain constant during each model time-step (one hour). The one-hour air concentrations for each pollutant in emission inventory are computed in a rectangular area for the whole period of meteorological data. The 1-hour average values form the basis for statistical analyses for other averaging periods. In normal practice the daily (24-hour), monthly (30-day) and annual statistical means are computed.

The results can be presented as isolines on map and in tabular form. The isolines give indication of those areas, where the expected air concentration levels of the pollutants exceed some prescribed value(s). By suitable choice of isoline separation these plots can be compared to air quality standards or regulatory limits. The modelling system is described in more detail by Karppinen et al. (1997). A Schematic picture of the local scale dispersion model UDM-FMI or CAR-FMI is shown in Figure 11.

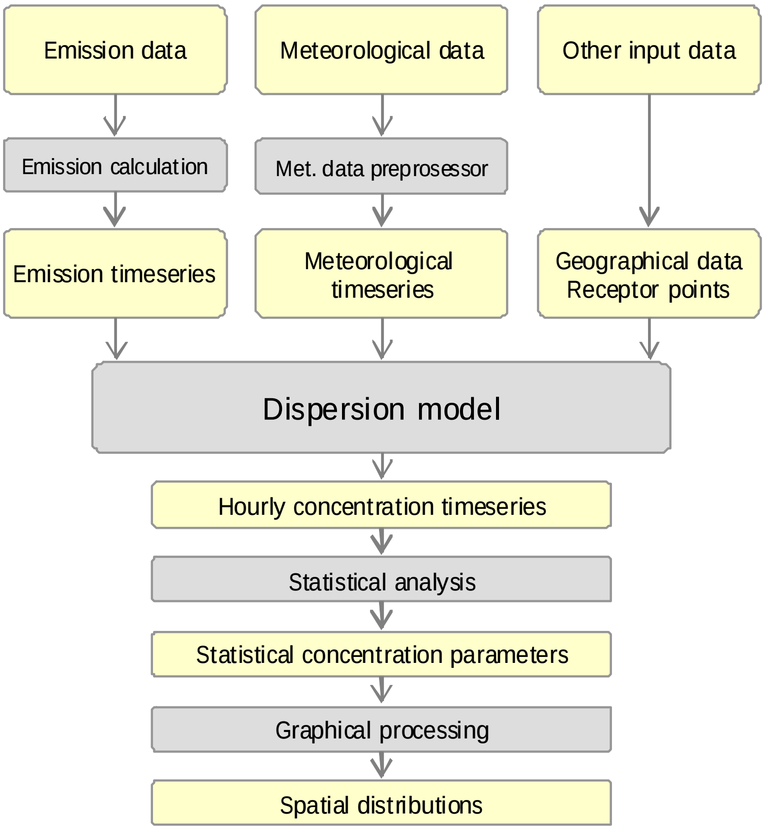


Figure 11 Schematic picture of the local scale dispersion model (UDM- FMI, CAR-FMI)

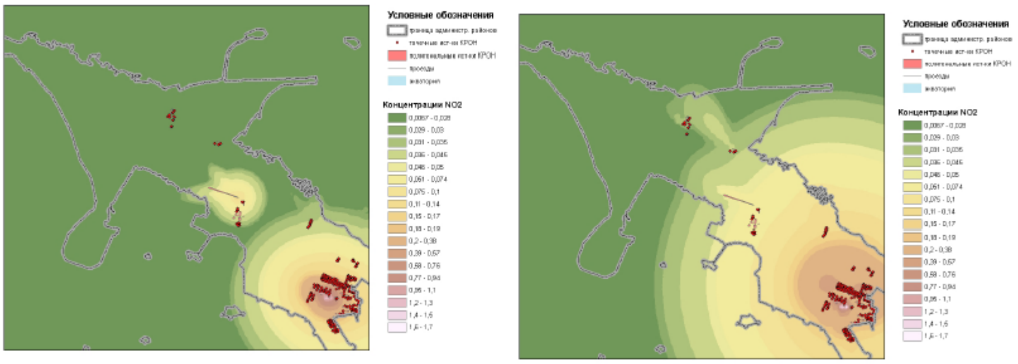
The basic meteorological parameters relevant for dispersion simulations are wind, ambient air temperature, boundary layer stability and mixing height. Wind determines the speed and direction of dispersion. Stability gives indication of the turbulent mixing rate inside the boundary layer. Turbulent mixing is the most important factor for pollutant dilution during transport. Mixing height describes the vertical extent of the plume.

Turbulence data and boundary layer height are not available from any routine base measurements. Indirect methods have therefore been introduced to calculate these parameters. The meteorological pre-processing model MPP-FMI developed in the Finnish Meteorological Institute (KARPPINEN et al., 1997 & 2000) has been utilised in this study. This pre-processing model is based on a slightly modified version of the energy budget method of van Ulden and Holtslag (1985). This method evaluates the turbulent heat and momentum fluxes in the atmospheric boundary layer by utilising the routinely available synoptic weather observations. The parameterisation of the boundary layer height is based on the boundary layer scaling and meteorological sounding data.

Meteorological time series for dispersion modelling are compiled by interpolating the weather data to the site of application with a straightforward distance-weighted interpolation. Several synoptic stations can be included in the interpolation. Time series normally cover from 1 to 3 years of data, depending on application.

7.2 Jonit Modeling Exercises

Joint modeling activities were started in the second phase (2006 – 2008) of the project by getting acquainted to the modeling tools and emission databases used in both countries. The first joint modeling exercise was done for the Kronstahdt island with some industrial sources. The dispersion of stationary sources was studied used both Finnish and Russian modeling tools and input parameters. As seen in Figure 12 the modeling results were quite similar despite of the different calculation methodologies of the models.



Finnish Model Results

Max. value – 1,32 mg/m3

Russian Model Results

Max. value – 1,69 mg/m3

Figure 12: Results of the first joint modelling exercise, the pilot study of Kronshtadt Island

Next joint pilot case study was made for the traffic. As the result of the comparison modeling there was recommendations given how to improve the accuracy of the traffic emission dispersion calculations by adding the ozone dependent chemical transformation of NOx to NO_2 in the modeling calculations and to fine down the calculation grid alongside the roads to get more detailed picture of the close vicinity of roads which is the most critical area regarding the traffic emissions. The emission factors of the different vehicle types were discussed although it was noted that the vehicle distributions and emission factors dependent on the vehicle type are different in St. Petersburg area and Finland. There is rather big difference i.eg in the mileage share of diesel cars that are quite common in Finland but not so common in St. Petersburg area. The example of traffic dispersion modeling result is shown in Figure 13.

As described in the chapter 6.2 there was many methodological improvements done based on the experiences of the joint modeling activities.

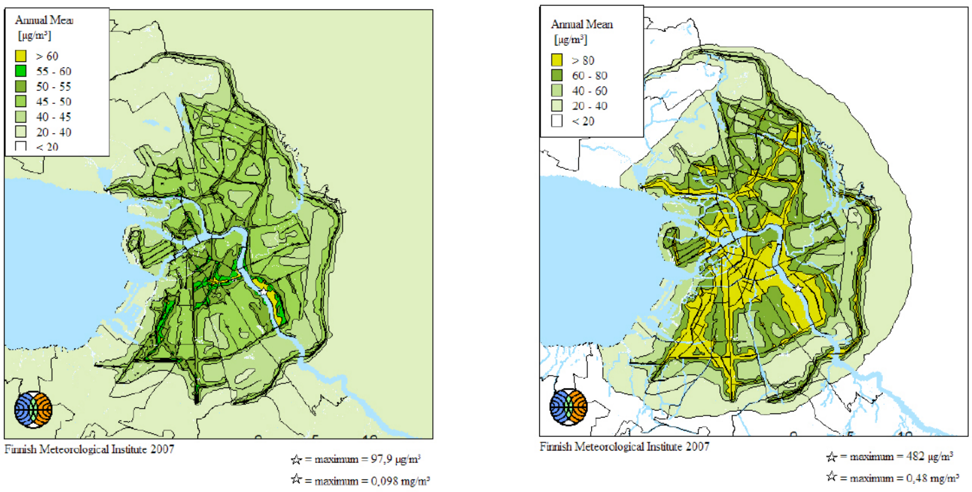


Figure 13: Results of the joint modelling exercise in case of traffic NO_X emissions and annual NO2 concentrations. Russian modelling on the left, Finnish modelling result on right.

The last large topic of the joint modeling exercises was the ship emissions and their impact to the air quality close to highly populated city center areas. The emission inventory system of the ship traffic in St. Petersburg was totally renewed as the emission of ship traffic and ports were not been considered before in the air quality assessment of the city of St. Petersburg with other major pollutant sources. The traditional way to assess the ship emissions was based on fuel consumption. The new emission inventory takes into consideration the different vessel types and the ship traffic information provided by ports. St. Petersburg is strongly dependent on ship traffic, there is at least 12 port terminals processing sea cargo ships close to the city area. Annually, the biggest Port, Sea port terminals are called by about 28 000 sea ships. Therefore, it is clear that ship emissions have an impact to the air quality of the city.

During the AQM project the knowledge and methodology of ship emissions and their impact to the air quality has increased considerably. FMI has offered support in developing the emission inventory and calculation methodology for the ship emissions. Dispersion calculations have been made and compared based on different emission inventory (STEAM model by FMI and new emission inventory methodology by Committee) and modeling methodologies and the results have been similar. However, there is still quite many uncertainties regarding the ship emissions (i. e. the validation of emission factors, used sulphur content in the fuel) which makes it important to validate the calculation methodologies and used input data by comparing the modeled results to the measured ones. Within the AQM project this last step of the validation was done very lightly and more information is recommended to be gathered under this topic in future. Example of comparison modeling of SO_2 emissions from ship traffic is shown in Figure 14.

The cooperation in the ship emissions continues during 2013 under the BSR INNOSHIP project. There are recent changes in the legislation concerning the SO_2-emissions of the ships which might have an influence also to the air quality impact of the shipping.

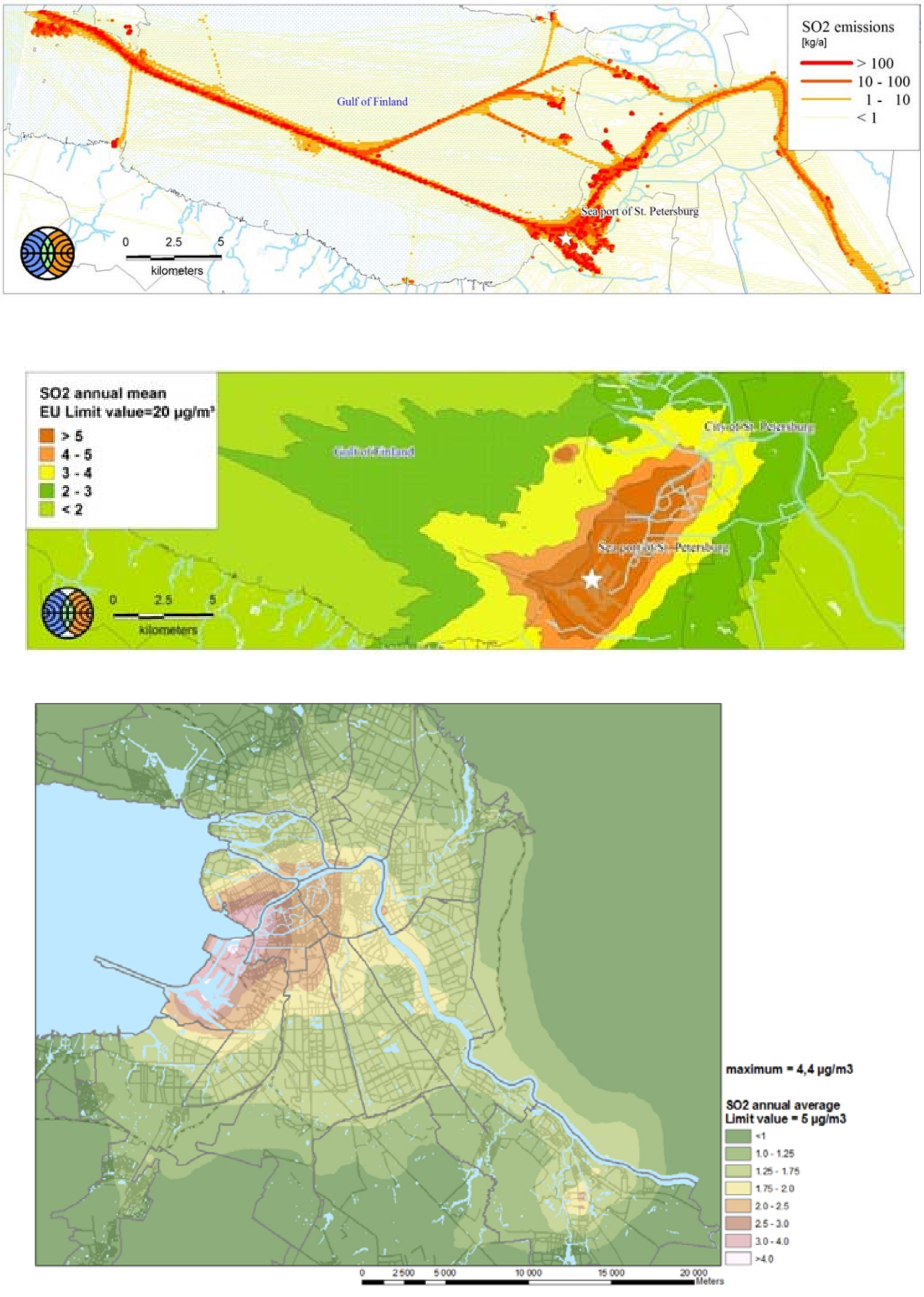


Figure 14: Results of the joint modelling exercise in case of ship traffic SO_2 emissions. At the top the result of the SO_2 emissions of ship traffic calculated by FMI STEAM model. in The middle: The dispersion of SO_2 emissions based on the emission inventory by STEAM model. At the bottom: Russian modelling results, which is based on the new ship emission inventory methodology.

Lessons Learnt

Despite of the different dispersion modeling techniques, the results of the comparison calculations were generally similar. According to AQ measurements and modeling there is a clear impact of ship emissions on the air quality in urban areas was identified. Dispersion modeling is important tool to support city planning and decision making and the use of dispersion modeling should be encouraged in the decision making processes (city planning, permitting etc.)
The dispersion modeling results should be validated by comparing the modeling results with the measured concentrations.

8 DOCUMENTS DEVELOPED IN THE FRAMEWORK OF THE PROJECT

8.1 Methodological Documents in St. Petersburg

The methodological materials providing for activity of the supervising network - monitoring of pollution of the atmospheric air with the system of Federal Service for Hydrometeorology and Monitoring of Environment are based on manual methods of selection and analysis of samples. There is not any integrated methodological documentation developed for atmospheric air monitoring automated systems set up and functioning on the territory of Russia. In this context, the development and implementation of methodological documents both for due operation of the Automated system of monitoring of the atmospheric air in St. Petersburg (hereinafter - ASM) and calculations for dispersal of pollutants, within the framework of the project, seems relevant and timely.

The methodological documents developed within the framework of the project may be divided conditionally into three groups:

1. methodological documents for organization of monitoring of the atmospheric air, control of observations and methods of measurement of parameters characterizing the quality and condition of the atmospheric air;
2. methodological recommendations and guidelines for assessment and provision of due quality of the monitoring data, their mathematical processing and use;
3. techniques aimed at improvement of the methods of account of pollutants dispersal, as illustrated in the tables below (16 – 18)

Table 16. Methodological documents developed in the framework of AQM project

№	Name of document as per ASM	Document or action in the project
Methodological documents for organization of monitoring of the atmospheric air, control of observations and methods of measurement of parameters characterizing the quality and condition of the atmospheric air		
1	Layout of placement of air quality control automated stations before 2010	Audit of ASM stations, report.
2	Methods of observations using mobile laboratories (approved by enactment of the Committee of 30.04.2009 № 50-р)	Comparative measurements of concentration of nitrogen and sulfur oxides on the equipment of mobile laboratory installed in the port area (on the territory of Baltiysky Works), 2011.
3	Certificate of approval of measuring methods type at the plants for control of polluted atmospheric air - automated unified УС-КВ RU.E.31.001A № 36224, 24.09.2009, in accordance with the Guidelines for operation of plant for control of atmospheric air pollution, automated unified «УС-КВ» - as developed by State Geology Unitary Enterprise Specialized Firm "Mineral", St. Petersburg, 2009, and М-МВИ-152-05. (Certificate № 242/89 of 26.05.2005).	Exchange of experience on organizing measurement of concentration of gaseous pollutants in the atmospheric air, using automated gas-analysis equipment (from 2005 to 2011.)
4	Certificate of approval of measuring methods for systems of automated sampling of suspended particles in the air LVS/MVS…DE.C.31.001.A № 35243, 08.08.2009	Exchange of experience on organizing measurement of concentration of fine-dispersed suspended particles PM_{10} and $PM_{2.5}$, using automated analyzers
5	Methods for measuring of specific pollutants: 3,4-benzpyrene (by automated programmable sampling and subsequent analysis of samples in the laboratory using high-performance liquid chromatography, according to М-МВИ № 167-05, Certificate № 242/148 of 31.10.2005); benzene, toluene (and - semi-quantitative sums of xylenes and ethylbenzene, according М-МВИ-166-05, Certificate № 242/139 of 24.10. 2005); formaldehyde, according to М-МВИ 179-06 (Certificate № 242/94 of 01.09.2006); phenol, according to М-МВИ 180-06 (Certificate № 242/95 of 01.09.2006).	Experience in organizing sampling and analysis of multiring aromatic hydrocarbons and aromatic hydrocarbons in the laboratory of Finnish Meteorological Institute (FMI). Conducting comparative measurements of organic compounds.
6	Procedures for quality control of primary monitoring data obtained with the automated system of atmospheric air monitoring in St. Petersburg (ASM) and their correction using a programme complex Airviro (Appendix 3 to Regulations for ASM – Enactments of the Committee of 18.11.2008 № 141-р and of 16.10.2009 № 98-р)	Comparative measurement of concentration of pollutants at ASM stations in 2007 and 2011, reports

Table 17. Methodological recommendation and guidelines developed in the framework of AQM project

Methodological recommendations and guidelines for assessment and provision of due quality of the monitoring data, their mathematical processing and use		
7	Methodological recommendations for providing due quality of measurement of concentration of pollutants in the atmospheric air, using the technical means of the Automated system of monitoring of the atmospheric air in St. Petersburg (approved by Enactment of the Committee of 18.11.2010 № 151-р)	Recommendations of the Finnish Meteorological Institute "QA/QC procedures at the air quality measurements in St. Petersburg" (FMI, 2008)
8	Methodological recommendations for assuring due quality of measurement of concentration of suspended particles (PM_{10} и $PM_{2.5}$) in the atmospheric air of St. Petersburg (approved by the Enactment of the Committee of 23.12.2011 № 177-р)	Recommendations of Finnish Meteorological Institute "QA/QC procedures at the air quality measurements in St. Petersburg "(FMI, 2008)
9	Methodological recommendations for presentation of data of monitoring of fine-dispersed suspended particles (PM_{10} and $PM_{2.5}$) in the atmospheric air of St. Petersburg (approved by the Enactment of the Committee of 20.05.2010 № 75-р)	Consultations on the use and enforcement of statutory regulations of the International and European laws: EN 12341:1999; EN 14907: 2005; WHO Air quality guidelines..; Directive 2008/50/EC.
10	Methodology for calculation of indicators of atmospheric air pollution in St. Petersburg according to the data of automated monitoring stations (approved by the Enactment of the Committee of 30.04.2009 № 49-р)	Acquaintance with the system of relative (index) assessment of the atmospheric air quality in Finland

Table 18. Techniques aimed to improve existing methods developed in the framework of AQM project

Techniques aimed at improvement of the methods of account of pollutants dispersal		
11	Method of calculating the annual emissions of movable sources on St. Petersburg highways on the basis of analysis of the transport flows structure (approved by the Enactment of the Committee of 17.02.2012 N 22-p)	Development of air quality assessment using the method for pollutants dispersal calculation
12	The methods for assessing emissions of harmful substances (pollutants) in the atmospheric air, coming from motor transport flows moving along the roads of St. Petersburg (approved by Enactment of the Committee of 17.02.2012 N 23-p)	Development of air quality assessment using the method for pollutants dispersal calculation
13	The methods for assessing the mass of harmful substances (pollutants) emitted by the water transport in the atmosphere of St. Petersburg (approved by the Committee от 05.06.2012 N 102-p)	Measurement and modelling of air quality parameters at the ports of St. Petersburg and Helsinki with the purpose to assess the impact of emissions from ships

Altogether, 8 methodological documents were developed under the Project, executed as regulatory technical documents. Of those, 5 deal with quality control and assurance, and 3 techniques aim at improvement of the methods for pollutant dispersion modeling. The Finnish experts participated in development of each of the methods and their contribution was really appreciable. All documents, according to requirements of the Russian legislation, were presented for the state environmental expert assessment with a view to establish compliance of the methods with the requirements set by technical regulations and environmental legislation. To make the expert assessment of each document, a State Environmental Expert Assessment Commission was formed of the leading city's specialists: scientists from the Voeikov MGO, RI Atmosphere, Mendeleev VNIIM, St. Petersburg State University and others). In the process of assessment, the methods were finalized following the experts' opinions. All methods presented at the state environmental expert assessment, were approved and commissioned by enactments of the Committee. The account of requirements of international and European regulations in the developed documents of the AMS methodological support makes it possible to use them as a universal basis for the development of up-to-date air monitoring systems (e.g. in CIS countries) to obtain reliable environmental information.

The methods were put into operation by the Committee and subordinate state company "Mineral". Most of methods developed within the Project are available in the Russian information search systems Codex, Guarant, Consultant+ and was distributed on CD as a part of hand-outs at three seminars on air quality monitoring organized by the Committee, attended by over 120 participants from 57 cities and regions of the Russian Federation.

All the methods were implemented by the Committee for Nature Management and subordinate state enterprise "Mineral." The most of methods developed within the project are available in the public domain - in the Russian information storage and retrieval systems Codex, Guarant, Consultant+ and was distributed on CD-ROM disks as a part of handout materials at three workshops on atmospheric air quality monitoring organized by the Committee, attended by over 120 participants from 57 cities and regions of the Russian Federation.

8.2 Methodologies and Recommendations in Quality Assurance

Along with the documents establishing the requirements and conditions for use of particular measurement facilities at ASM: technical regulations, operating instructions setting the structure and order of technical maintenance of the measuring equipment, guidance on the quality of the testing laboratory (environmental monitoring) and methods for verification of measurement facilities, methodical recommendations were developed within the framework of the Russian-Finnish cooperation, describing the procedures necessary to ensure, "guarantee" and control the required level of measurements quality (Quality assurance and quality control, hereinafter - QA/QC), of more or less general and universal character:

Methodical recommendations assuring due quality of measurement of pollutants concentration in the atmospheric air, using the technical facilities of the Automated system of monitoring of the atmospheric air in St. Petersburg;

Methodical recommendations assuring due quality of measurement of concentration of suspended particles (PM_{10} and $PM_{2.5}$) in the atmospheric air of St. Petersburg (hereinafter - methodological recommendations for the quality of measurement of PM concentration).

The above methodical recommendations underwent environmental state examination and were approved for use in ASM by enactments of the Committee.

Methodical recommendations assuring due quality of measurement of concentration of gas pollutants, developed in 2010 by state company "Mineral" with the participation of Finnish experts, for the purpose of continuous monitoring of atmospheric air pollution, compliance with the requirements to secure and control quality data, obtaining reliable data on the condition of the atmospheric air.

Methodological recommendations for quality of measuring of PM concentrations were developed in 2011 by the state company "Mineral", with the participation of Finnish experts, to conduct continuous observation (monitoring) of the content of $PM_{2,5}$ and PM_{10} in the atmospheric air, comply the requirements to secure and control quality data derived from monitoring, obtain reliable data on the content of $PM_{2,5}$ and PM_{10} in the atmospheric air.

The QA/QC procedures described in the methodological recommendations meet the national standards and the standards developed by the European Committee for Standardization; they may be complied with to meet the assignments relating to data quality, as set by the European Directives. The use of the described QA/QC measures makes it possible to obtain reliable data connected with monitoring of the atmospheric air, comparable with the data of the European monitoring systems.

Methodologies to improve the modelling methods

Due to the fact that St. Petersburg is the second largest city in Russia in the number of motor transport and intensity of traffic, improvement of the methodological framework for assessment of quantitative and qualitative characteristics of emissions from motor vehicles is a priority task in the atmospheric air protection. In recent years the automobile fleet of St. Petersburg has renewed and reached the automobile fleet of major European cities in its structure. Therefore, this engendered a need to introduce classification of motor transport on the European principles and to seriously improve "The methods for assessing the discharge of harmful substances (pollutants) in the atmospheric air from the motor transport flows moving on the roads of St. Petersburg." It took into account the specificity of structure of motor transport flows moving along the roads and the specificity of the road and traffic network of the city.

The methods of calculating annual emissions of movable sources in the highways of St. Petersburg on the basis of analysis of the structure of motor transport flows was developed for the first time in Russia. The estimation formulas used in this paper make it possible to account the daily, weekly (weekdays and weekends) and seasonal (winter/summer) variations of intensity of transport flows. The conversion coefficients were obtained for different types of roads in St. Petersburg (central, radial and transit) on the basis of summarized data for temporal variability of motor transport flows intensity, taking into account the non-stationarity of the road traffic.

The methods of assessing the mass of harmful substances (pollutants) emitted by water transport in the atmosphere of St. Petersburg takes into account the change in emission by ships in different modes of movement, as well as the type of ship and the composition of fuel used. The results of in-situ measurements carried out in 2011 by the Finnish specialists made it possible:

- to specify the values of the correction factor kkr for specific average weighted discharge of nitrogen oxides - eNOx, when considering the operation of main propulsion plant during the cruising regime of a moving vessel,
- to re-assess the mass concentration of sulfur in fuel using the data of bunkering companies;
- to consider that, according to the Finnish measurements data, 30% of vessels use heavy fuel grades as a basic fuel for main diesels (the method uses the content of sulfur for calculations: Cs [%] = 1,0 %), while 70% of ships sail using the diesel fuel (the method uses the content of sulfur for calculations in 2010: Cs [%] = 0,17 %).

With the revision of the Method for assessing the mass of harmful substances (pollutants) discharged by water transport in the atmosphere of St. Petersburg, we have received a valid coincidence of the in-situ measurements data with the results of statistical evaluation of factors of specific average weighted discharge per unit of output of ship propulsion plants.

9 DISSEMINATION OF THE PROJECT RESULTS

As described in the previous chapter, the project results and experiences have been widely disseminated locally in both countries and in addition some international publicity has been reached. Participating some of the meetings and conferences has resulted also some media coverage; articles in newspapers such as; Helsingin Sanomat, Air Pollution Prevention magazine “ilmansuojelulehti” by FAPPS.

Figure 15: Map of dissemination of the experience in establishing and operation the AMS

9.1 National Conferences and events

Some highlights of the publicity and dissemination of the project results in Finland and Russia:

2005

- August 22-25, Participation in Finnish Air Pollution Monitoring Conference, Lappeenranta (Finland). The event was widely covered by mass media: two radio channels, local and national TV, newspapers publications etc. In the framework of the Conference the further cooperation was discussed. The automated air monitoring system of St Petersburg was presented. Besides, a mobile monitoring station was brought from St. Petersburg and made measurements publically in the central square of Lappeenranta. Both monitoring system and mobile facility were presented to project coordinators from the Finnish Ministry of the Environment.

2007

- August 20-22, The Russian partners took part in the traditional Lappeenranta Air Quality Days conference (Finland). Joint partner meetings with coordinators from the Finnish MoE were held to discuss cooperation plans. The Russian delegation visited Virolahti air monitoring station.

2008

- October 2008 Delegation of the Environmental Authority of Istanbul, Turkey, visited St. Petersburg to study experience is establishing and maintenance of the air monitoring system. The outcomes of the Russian-Finnish joint activities were presented.

2009

- August 18-19, Visit to Lappeenranta Air Quality Days Conference (Finland) and side event to discuss the air monitoring cooperation in the Baltic Sea area. The Russian experts presented results of evaluation of negative impact of ships emissions on the territory of St. Petersburg. A workshop was organized to discuss a project proposal to the European programme Baltic Region to implement an international project InnoShip. The project proposal was based on cooperation experiences from the AQM project
- 9-10 November 2009 seminar on monitoring with representatives of the Republic of Kazakhstan
- 25-27 November 2009 seminar on monitoring with representatives of China

Figure 16: the Russian project partners visiting in Lappeenranta Air Quality Days in 2005

9.2 International Conferences

Some highlights of the publicity and dissemination of the project results in International Conferences and Meetings:

- 21-26 November 2005, in St. Petersburg as part of the project "Support to the Environmental Control Department of St Petersburg“. Seminar with DCMR Holland.
- In July 2008, the experience of St. Petersburg to assess air quality calculation methods was presented at a seminar held at the RI Atmosfera within the Russian-Dutch project on air quality.
- March 3-5, 2009 International Conference on the Air Protection and the prospects for cooperation in this field. Tartu, Estonia.
- In 2010 and 2011 the results of practical application of methods to assess negative impact of ship emissions were presented at the 13th and 14th “Atmosphere” international congresses, which took place in St. Petersburg.
- At the international scientific conference PETrA 2011 (Pollution and Environment - Treatment of Air), which was held in Prague, Czechia, on May 17–20, 2011, the representatives of FMI and the Committee made a joint presentation “Ship emission impact on urban air quality in the Gulf of Finland” based on efficient international cooperation, using AQM project as example.

9.3 Contacts with representatives of Russian Regions

Besides, delegations from Russian cities and regions visited the Committee to get familiarized with the AMS and the cooperation experiences.

- April 2006 - administration of the city of Tuapse.
- December 20, 2006 the Sverdlovsk regional "Centre for Environmental Monitoring and Control" (Government of Sverdlovsk Region).
- Consulting representatives of FGU "Center for Laboratory Analysis and Technical Measurements of the Volga Federal District," (Federal Service for Environmental, Technological and Nuclear Supervision) Cheboksary.
- Automated system for air quality control - JSC "Tulachermet" - 2 stations.
- Conducted to familiarize Commission Central Office Russian Emergencies Ministry with automated air monitoring and ARMS of St. Petersburg (21.06.2007).
- Government of Ryazan environmental management Ryazan region - will order the automatic station.
- October 15, 2008. Consulting representatives of the administration of the municipal entity Krasnodar city. (2008 2 automatic stations).

- November 26, 2008 Workshop: Experience in organizing and conducting air monitoring in St. Petersburg. Prospects for the development of regional monitoring systems.
- 3-5 June 2009 a workshop with representatives of the Republic of Dagestan on the issues of automated air monitoring.
- June 24, 2009 workshop with representatives of Kalinigrad on the organization of automated systems for monitoring air quality.
- September 16, 2010 Workshop on air monitoring with the Vologda
- September 22-23, 2010 seminar "Impact of transport on air quality."
- May 23, 2011 Seminar air regions
- March 22, 2012 Ecology of a big city. Seminar 'THE ENVIRONMENTAL MONITORING IN CITIES "

Some examples of implementation of St. Petersburg experience in Russian regions and cities:

- Arkhangelsk: Starting from 1 July 2009, a fixed automated air monitoring station was launched. The equipment measures the average twenty-minute concentrations of carbon monoxide, nitrogen dioxide, nitrogen oxide, hydrogen sulfide, particulate matter.
- Perm: The air monitoring system was established consisting of 3 automated stations. 5 parameters are measured.
- Sverdlovsk Region: an air monitoring system of 11 automatic stations is operating (Yekaterinburg, Pervouralsk, Nizhny Tagil, Kamensk-Uralsk, Krasnouralsk, Upper Pyshma, Asbestos, Kirovgrad, Revda or less).
- Sochi: 4 stations, located in the village of Krasnaya Polyana, Adler and Central regions of Sochi, in the Imereti Valley.
- Cheboksary (Chuvashia): adopted a program "Greening in the Chuvash Republic for 2010-2015" which foresees the construction of automated air monitoring stations.
- Sterlitamak (Bashkortostan): 2 stations.
- Khabarovsk: At the end of December 2012 the Khabarovsk regional center for environmental monitoring and disaster prediction of an automated post air monitoring.

10 PROJECT RESULTS

10.1 Benefits to Russia/St. Petersburg

The anticipated results/expectations of the Russian partners in the beginning of the cooperation were:

- to optimize the equipment used in the monitoring stations;
- to increase the number of measurement channels, extending measurement methods (passive sampling);
- to develop the methodological support of the system's operation;
- to strengthen the metrological support of the monitoring system;
- to optimize the data processing system;
- to develop of modelling methods using filed monitoring data;
- to organize the monitoring data presentation to various target groups, including the general public;
- to develop a system for data exchange between the project participants with the potentiality to extend the number of participants in the data exchange.

The assessment of the Project's outcomes in the end shows that the real deliverables of the activities are much beyond the expectation. The results of the AQM cooperation are very important for the Russian side and do have significance at both national and St. Petersburg levels:

At the level of the Russian Federation:

1. The most up-to-date system of the air quality monitoring in the Russian Federation was developed, which may serve as a model for the monitoring system of Roshydromet (The Federal Service for Hydrometeorology and Monitoring of Environment);

2. The experience of the on-line exchange of the background air pollution information, obtained at automated air monitoring stations, enables to establish a national system of the background air pollution information exchange;

3. The Project activity in assessment of the ship emissions and their impact on the adjacent area, initiated an international project InnoShip, whose expected results will be very useful for the Russian Sea Ports;

4. The Project experience in organization and operation of automated air monitoring system and the use of pollutant dispersion modelling methods to support managerial decision-making, is continually disseminated.

At the level of St. Petersburg:

1. The needs of the authorities of St. Petersburg, legal and natural persons in reliable air quality information were met, necessary for prevention and/or decrease of adverse effects of the environmental changes;

2. Five (5) methodological documents on establishing the air monitoring network, and on implementing the air monitoring were developed and inacted;

3. Four (4) methods for measuring the parameters, which characterize the ambient air condition were developed and integrated in the State Register;

4. Four (4) methodological recommendations and guidelines on assessment and assurance of the monitoring data quality, on their numerical processing and their application, were developed, assessed by the state environmental expert commission, and enacted;

5. Three (3) methodological documents aimed to improve dispersion modelling were developed, assessed by the state environmental expert commission, and enacted;

6. Methodological documents developed within the Project are available in the Russian information search systems Codex, Guarant, Consultant+ and were disseminated by the Committee to interested cities and regions of the Russian Federation;

7. The introduction of an automated air monitoring system in St. Petersburg, matching the European standards, contributed to the FIFA's positive decision to hold the World Football Championship in Russia in 2018, including in the football facilities of St. Petersburg. Among the FIFA's requirements to countries hosting football events there is the following clause: "Host cities have to provide a detailed air quality assessment for the five years prior to the event. This must be accompanied by information accounting for any change in air quality and information regarding whether the air quality is likely to change during the FIFA World Cup" (see chapter "Environmental issues during the FIFA World Cup", p. 47 of "Football Stadiums Technical Recommendations and Requirements", 5th edition, 2011, at http://www.fifa.com);

8. Assessment of the air quality in the city according to the EU standards and indicators contributed to attracting both investments and tourists;

9. Integration of modelling/calculation methods of the air quality assessment, including, along with the pollutant dispersion modelling, the calculation of pollutant fall-out on the territory, the calculation of health risks depending on the air pollution level, facilitated integration of new elements of the air quality management indicators, such as:

- dynamics of changing the areas with above-standard level of the air pollution caused by industrial and traffic emissions;
- dynamics of changing the number of residential houses and population on the territory with above-standard level of the air pollution;

- dynamics of changing the number of residential houses and population on the territory with increased level of health risks caused by the air pollution.

10. The Project experience was utmostly used in developing a long-term target programme of St. Petersburg “Establishment and Support to Operation of Territorial Environmental Monitoring Systems in St. Petersburg for the period from 2013 to 2017 ", adopted by the Government of St. Petersburg in May 2012, provided with the budget of 575236, 22 roubles

11. The information exchange on climate change issues in the framework of the Project, contributed to the launch of activities in assessment of the impact of climate changes on the urban economy in June 2012

10.2 Benefits to Finland /FMI

During the project the FMI researchers have had a possibility to get to know the methodologies and practices used in air quality monitoring in St Petersburg. During the several measurement campaigns, comparison measurements and modeling exercises the researchers have learned to know about different assessment techniques as well as the different concentration levels of various atmospheric pollutants (i.e. ozone, nitrogen oxides, sulphur dioxide, PAHs, aromatic hydrocarbons) in the city and also in the background stations areas in St. Petersburg. In return the FMI researchers have had the opportunity to inform about the European air quality legislation and practices.

One of the major benefits of the project is the on-line air quality data exchange. It is useful to have the detailed information of the existing concentration levels close to the St. Petersburg area as the large city area locates in the vicinity of Finland. Particularly interesting are the long range transportation episodes of i.e. particulates that can be monitored from the background stations. It is also beneficial that during the years the project has lasted, the researchers have succeeded to establish good relations to the air quality researchers and the officers responsible for air quality issues in St Petersburg. These relationships are of utmost importance when planning new projects in the future as the spinoff project BSR INNOSHIP has shown.

Beside the increased competence of experts, the project itself is a valuable reference while preparing other international air quality projects.

10.3 Spin-Offs and Other Side-Effects

Beside the dissemination of project results, a new networks and connections between experts and organisations in Finland and St. Petersburg have been created. In practice, an excellent example of this is a BSR Innoship project (http://www.baltic.org/projects/bsr_innoship) which was originally launched by the AQM project partners. INNOSHIP project unites 18 partner organisations from 10 countries around Baltic Sea Region to work together towards clean and competitive shipping in Baltic Sea area. Finnish Meteorological institute, Baltic Institute of Finland and the City of St. Petersburg are working together in INNOSHIP project.

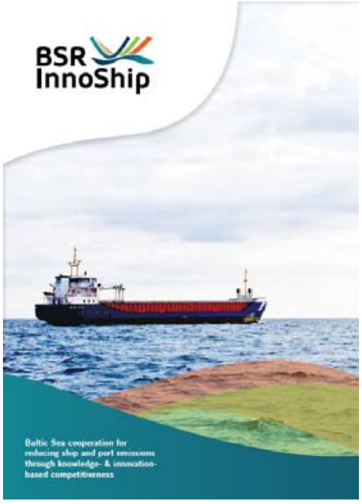


Figure 17. BSR Innoship project funded by EU is the spinoff of the AQM project.

10.4 Sustainability of Project Results

There is strong foundation to ensure the sustainability of the project results. The project focus was to enhance practical operational processes and methods on both sides. This has been done successfully during nine years of cooperation in various air quality assessment processes. Tens of legal documents were developed during the project and implemented in practice. Methodological documents improved and created during the project have passed the expert evaluation in and become official practices (Chapter 5.2).

The results and experiences of the project have been widely disseminated in Russia and Finland (Chapter 6) which ensures the sustainability of the project results for wider usage besides the project partners. Active dissemination of project results increases also the environmental awareness, which was one the objectives of the project.

The City of St. Petersburg has done considerable investments to develop the Air Quality monitoring network of the city of St. Petersburg during the AQM project. Economical and human resources have been well secured. The City of St. Petersburg has also systematic plans for the future development of the Air Quality monitoring network and the funding decisions for the development are also made. Thus, the sustainability of the project results seem confirmed.

One of the achievements of the project is the online data exchange between six air quality background stations in St. Petersburg area and Finland. At this stage the continuation of data exchange is still open, but there is a common will to continue or extend the data exchange. However, the development of the online information exchange will require resources. There is also interest to utlise the online information exchange data internationally for example in international research projects.

The Ship emission impact studied started within the AQM project have continued in large scale EU funded project INNOSHIP where bilateral cooperation was extended to the international project. These projects have created better understanding of the impact of ship emissions to the air quality around Baltic Sea. This work will certainly continue while there have been recent legislative decisions to reduce the ship emissions around Baltic Sea area (SECA-area). During the AQM project, the new Ship emission inventory system was developed to the City of St. Petersburg and quite many methodological documents were developed regarding the ship emission inventory. Those documents will be followed when the yearly emission inventories are carried out in St. Petersburg area.

New on-going ENPI ILEPRA (Intercluster Laboratory on Environmental Protection and Risk Assessment) can also utilize some of the information produced in AQM project. Both project partners Finnish Meteorological Institute and City of St. Petersburg are included to the ILEPRA project.

New cooperation topics are actively search for and it is likely that cooperation will continue in future in one form or another.

10.5 Key Lessons Learnt

The practical level air quality cooperation between the City of St. Petersburg and Finnish Meteorological Institute has been a learning journey for both partners. The project experiences have offered great learning opportunities for experts and organisations involved to the project. There are many practical lessons learned during the long-term cooperation which are described more detailed in previous chapters of the report. However, the main key lessons learnt can be highlighted based on the experiences from AQM project:

- Twinning partnership and very practical approach is an excellent tool to achieve long term sustainable results
- Experiences from the joint activities have been important for the both project partners (win-win)
- Increased competence of Experts and institutions working in the project
- New knowledge about the legislative differences and methodological differences between Finland and Russia; nevertheless the information and methodologies comparable
- Information exchange between the project partners in General has been very useful
- External project management was not found very useful, lack of substance knowledge caused some communication problems and also some inconsistency in planning the practical cooperation activities

- Project has been good reference for other international projects

Thus, the overall project has been very beneficial to the both project partners. Numerous project results and achievements have been reached during the co-operation and the sustainability of the project results seems to be promising. The project results have also been widely disseminated in Finland and St. Petersburg. The long-term cooperation has enabled to see also the impact of the cooperation activities to the practical level work.

11 USAGE OF AIR QUALITY INFORMATION

11.1 In St. Petersburg area

Major fields of the usage of the air quality information in St. Petersburg:

- Air quality reports based on monitoring data are submitted to the City Government on weekly basis.
- Updating of the air quality data at the Environmental portal of St. Petersburg on monthly basis.
- The so-called “Environmental balance”, a document providing detailed evaluation the environment quality in the city, is developed by the Committee on annual basis.
- City planning needs.
- Information for environmental inspection.
- Cooperation with the Sanitary survey.
- Replies to citizen’s queries/complaint.

Ensuring the due quality of the atmospheric air to meet the relevant national standards is one of the priority tasks of industrialized subjects of the Russian Federation in the field of environmental protection. In particular, by the Decree of the Russian Federation Government № 322 dated 15.04.2009, the parameters of the atmospheric air quality are included in the reporting activity of the executive authorities of the Russian Federation subjects. The characteristics of the atmospheric air quality are used as well in assessing the standards of living in the regions of the Russian Federation.

Among appeals of the city residents to the executive authorities of St. Petersburg, those related to the quality of the atmospheric air exceed 10% of the total number of applications. This fact evidences the residents' high demand for information about the negative impact on atmospheric air.

One may single out the following target groups as consumers of information about the level of pollution of the atmospheric air: regional and federal authorities, consulting firms engaged in assessment of planned activities on the environment, representatives of environmental services of enterprises, investors and the public.

Among the public authorities the main consumers of information about the level of pollution of the atmospheric air, as obtained by modelling results, are employees of the environmental control bodies. Despite the fact that, in accordance with Russian law, the simulation results may not be a proof of violations in the domain of atmospheric air protection, the obtained data can be used in implementation of control measures.

The data on the impact of motor transport emissions on the atmospheric air quality, obtained by modelling of dispersal of pollutants, are used in developing programmes of activities for developing the road network by a regional executive body responsible for development of the transport infrastructure. The modelling tools have demonstrated as well their efficiency in designing of industrial zones and solving other urban planning tasks.

When deciding on the placement of new enterprises, the simulation results are used by executive bodies taking decisions on construction of socially important objects such as waste processing plants or heat engineering facilities. In addition, the data on the estimated level of atmospheric pollution are used by engineering design and consulting companies in assessing of environmental impact of industrial enterprises.

Among the principal consumers of results of summary calculations regarding the quality of the atmospheric air are medical workers engaged in sanitary and epidemiological surveillance. The data on distribution of both major and specific pollutants are used by them to assess the risk to health of the population, caused by emissions in the atmosphere. Here the most important factor is the account of the maximum possible number of pollutants, as many substances essentially affect one's health, even in small concentrations. To assess the health risks in Russia, a special method estimating health risks was developed and approved by the Ministry of Health, based on the results of pollutants dispersal modelling.

With increasing environmental awareness of the population and active participation of public organizations in the sphere of environmental protection, the queries regarding the environmental quality coming from the residents become more complex and competent. In view of the complexity and high cost of organizing field observations, the most effective way to meet the demand for information on air quality is modelling. Model calculations also form the basis for organization of monitoring observations with the use of movable measuring laboratories.

11.2 In Finland

In principle, all the air quality information produced in Finland by the FMI, municipalities or cities is public. However, there are exceptions for this the publicity principle; the measurement campaigns made for the industries or companies as specific consultancy project. Usually these kinds of projects are carried out inside the industrial areas where the European Union's limit values do not apply. Finnish Meteorological Institute maintains the national air quality database and air quality portal (www.airquality.fi) where all the air quality monitoring data measured in Finland by different monitoring networks is published on-line. Therefore, anyone interested on air quality can go to visit the webpage and see the current air quality situation presented as air quality index and actual hourly concentrations.

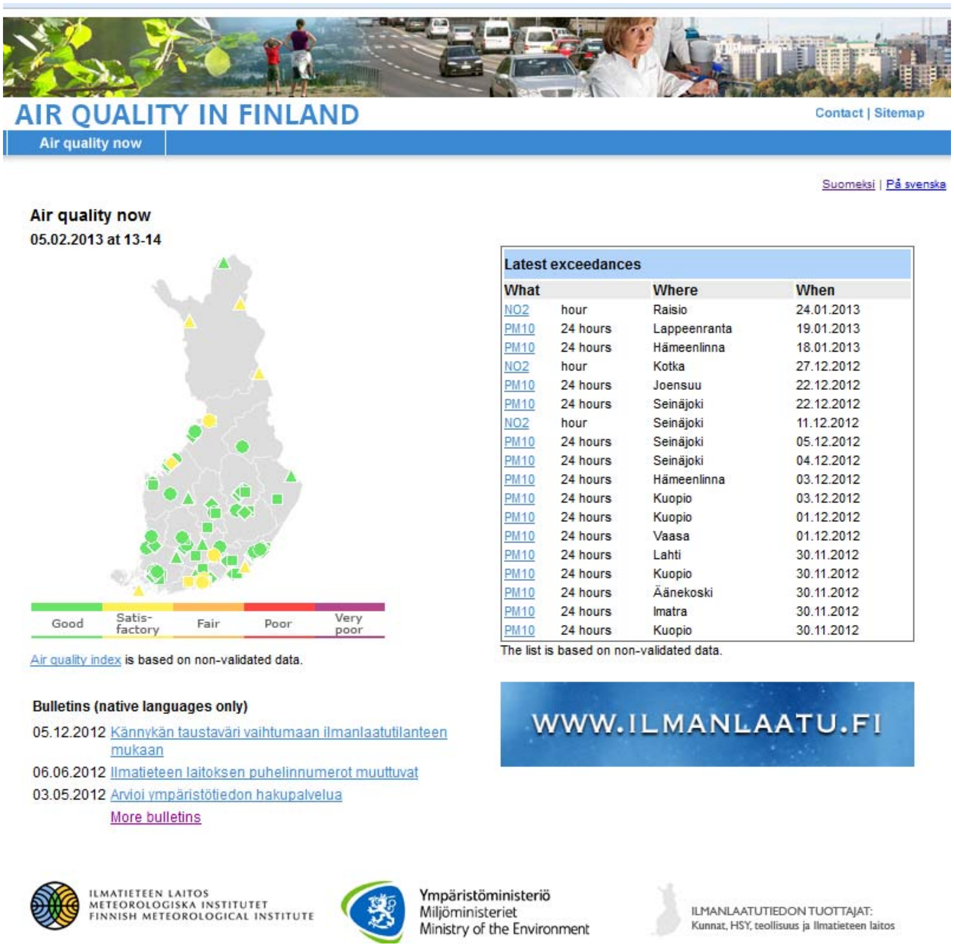


Figure 18. FMI maintains the public Air Quality Portal where all the air quality data is collected on-line (http://www.ilmanlaatu.fi/ilmanyt/nyt/ilmanyt.php)

In Finland, the municipalities and cities are responsible of the air quality assessments within the city areas. Therefore, while the cities carry out the air quality monitoring and assessments in the urban areas they are also responsible of informing the citizens if the air quality is poor or the concentration levels of pollutants reach the warning threshold level.

FMI is responsible of following the background air quality in clean background areas and is responsible to give the warnings of high ozone concentrations if they exceed the warning limit defined in the air quality directive. FMI provides the air quality forecasts (that are based on the numerical weather prediction models and dispersion models) to the some of the biggest cities in Finland. In this way, the cities and municipalities may inform the citizens about the poor air quality approximately about 48 hours in advance.

Air quality data and particularly dispersion modeling data, is widely used in everyday decision making processes i.e. in city, traffic and land usage planning as well as industrial applications as part of their environmental impact assessments (EIA) or process planning (studying the impact of cleaner technologies, optimising the stack height and so on. If the dispersion modeling assessment is part of the public land usage planning, the air quality data is open for public.

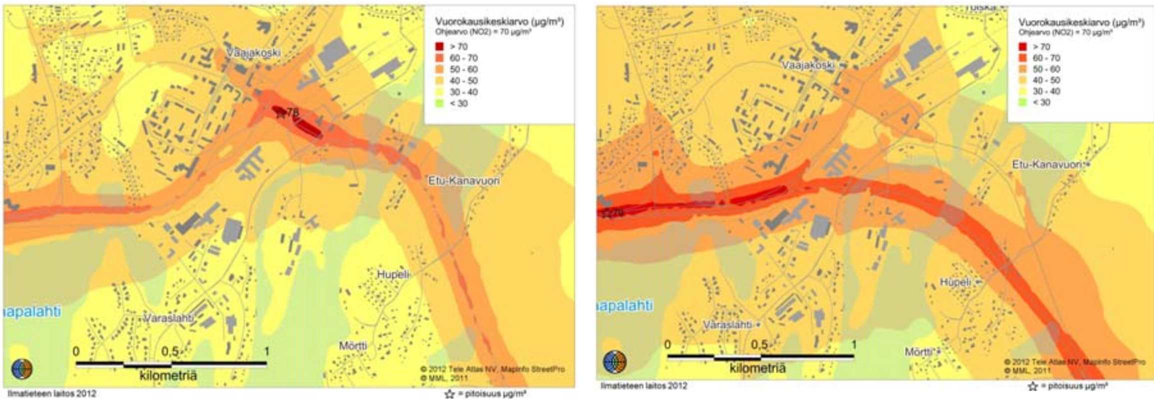
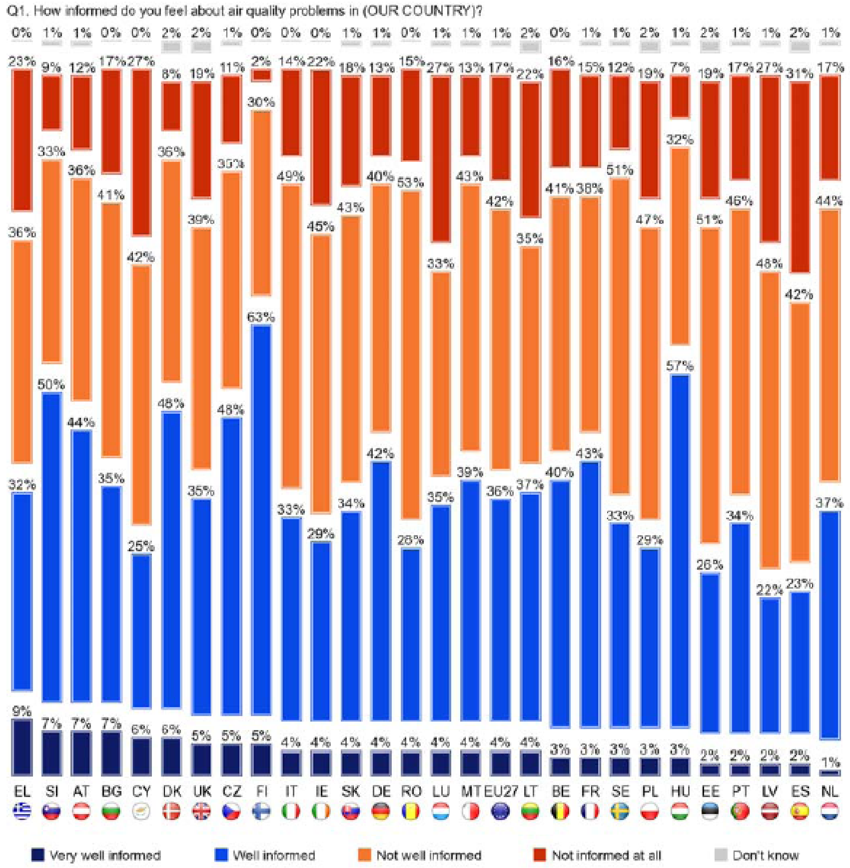


Figure 19 . Example of dispersion modeling result maps which have been used to support city planning decisions, inthis case the alignment of a new road was studied.

In addition to monitoring and dispersion modeling data published by the municipalities, cities and FMI there is a lot of research data available for public. There are societies such as FAPPS that are actively distributing the latest air quality information and new research study results in the field. Some companies (i.e. Medixine) are offering the mobile air quality information services by providing the mobile air quality data services to the mobile phone users.

According to the recent study (EC, 2013) made by European Commission, the Europeans generally would like to get more information about the air quality. However, the study results show that in Europe, Finnish people are the most pleased with the amount of air quality information shared in public. In picture 20 is shown that about 68 % of Finns think that they are getting the air quality data at least to some extent. About 20 % of Finns say that they have suffered about the poor air quality.



Picture 20. Recent study in made in shows how people feel being informed about the air quality problems (*EC, 2013*)

12 RECOMMENDATIONS FOR FUTURE COOPERATION

The cooperation within the framework of "Development of air quality monitoring system in St. Petersburg" Project has shown the effectiveness of international cooperation at the level of Russian Federation regions. High-performance concrete results, as well as the multiplier effects of completed projects by means of sharing the experience from one region to other Russian regions are achieved by determining the specific regional requirements for the environmental monitoring data, as well as the regional financial capacity assessment necessary to develop monitoring systems.

The cooperation allows sharing the data about changes in national legislation requirements and technological development. Implementation of the project has shown the importance of exchanging the observational data online.

Based on the foregoing, it seems urgent to continue cooperation in the following directions.

1. The on-line data exchange of background air quality monitoring. The quality of the data obtained with the help of automated atmospheric air monitoring system in Saint Petersburg allows using them for integrating into the atmospheric air quality monitoring system in European cities. The background concentration monitoring data are of particular importance as far as such an exchange is concerned. It is necessary to preserve the existing data exchange volume within the further cooperation framework, as well as there is a possibility to expand it using the data of other monitoring stations or recruiting partners from neighboring countries.

In order to implement this cooperation, it is necessary to conclude an agreement between the Committee and the PMI. Also, within the framework of the agreement it is necessary to carry out regular seminars on such topics as legislative alterations in atmospheric air quality protection, methodological approaches for atmospheric air quality monitoring, as well as new technological solutions in this area.

2. Assessing the impact of changing climatic parameters on urban areas. Development of cities and urban infrastructure complexity lead to increased vulnerability to extreme climate events. This factor, together with climate change, expressed the increasing frequency and intensity of extreme climatic events, leading to repeated increase in economic losses. Exchange of experience in adapting to the conditions of urban areas to climate change is a priority for the sustainable development of the region, as well as reducing investment risks and environmental damage. As part of the further cooperation appropriate to provide workshops on the impact of climate change parameters on the urban areas.

3. Reducing the negative impact of passenger water transport in urban areas. Construction of a new passenger port in St. Petersburg, together with measures to simplify the visa regime for passengers arriving on cruise ships, has encouraged the rapid growth in the number of passenger ships coming into the city. Installed new ferry line between Helsinki, Stockholm, St. Petersburg and other Baltic ports. Taking into account that in most modern port cities Baltic port cargo terminals are located far away from residential areas, the greatest impact on residential neighborhoods have just emissions of passenger ships. In addition, the impact of emissions from passenger ships in marginally addressed in international projects to explore the issue of emissions from shipping on the Baltic Sea region. As part of the further cooperation appropriate to provide seminars on reducing the negative impact of passenger water transport in urban areas.

4. Radiation safety is a priority in the field of environmental safety areas. In this regard, it seems urgent cooperation in automatic monitoring radiation levels, for natural and man-made sources of radiation, information systems and public awareness about the level of radiation.

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