ENVIRONMENTAL INDICATORS:

CASE STUDY:
AIR EMISSIONS INVENTORY,
AIR POLLUTION
MONITORING AND MODELING
IN KAZAKHSTAN

within the framework of the
Convention on Long-Range Transboundary Air Pollution[1]

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INTRODUCTION

General Information about the Republic of Kazakhstan

Kazakhstan is situated in Central Asia and has borders with the Russian Federation to the North, China to the East, and Uzbekistan, Turkmenistan and Kyrgyzstan to the South. Total area of the country is 2.72 million km^2. As of January 1, 2003, the population was 14.86 million, including 8.416 million people (56.6%) in urban centers and 6.446 million (43.4%) in rural areas. Density of population in the Republic is 5.5 people per km^2.

Natural Resources and Economic Structure. Kazakhstan, situated in the central part of Eurasian continent, is rich in natural resources. The assessed deposits of petroleum, coal, ferrous and non-ferrous ores, and phosphates can assure the long-term requirements of the Republic. Underground reserves contain great resources of minerals, ferrous ores, non-ferrous and rare metals, precious metals, construction materials and finishing stone materials. The country occupies the first place in the world in explored reserves of zinc, wolfram, and barite, second place in reserves of silver, lead and chromites, third place in copper and fluorite, fourth place in molybdenum, and sixth place in gold. Within the total of countries of Eastern Europe, the Caucasus and Central Asia (EECCA), Kazakhstan holds a 90% share of total reserves of chromites, 60% of wolfram, 50% of lead, 40% of zinc and copper, 30% of bauxites, 25% of phosphates, 15% of ferrous ore, and more than 10% of coal. In the western region there are substantial reserves of petroleum and gas, allowing Kazakhstan to be one of world's largest oil producing countries.

In terms of economic structure, the largest share of production is found in the extractive and primary processing sectors. The main industrial sectors are fuel and energy, mining and smelting, agro-industrial and chemicals. Intensive development of mining and smelting and oil-processing sectors have resulted in the current industrial base of the country, made up of the most environmentally hazardous industries, such as fuel production, metallurgy, chemical and petrochemical production. In general, the economy of the Republic during the transition period experienced a decline in production in all of the basic economic sectors, and in recent years a stabilisation and revival of economic activity was seen. The data show that due to this economic upsurge, starting in 1998, volumes of polluting emissions into the atmosphere have also started to increase.

From 1991 to 1995, a reduction of production volumes was observed. In the second half of the decade (1996-2000), production volumes started growing. On average, the annual increase was 3.1%. In some industrial sectors in recent years, production volumes grew significantly and the rate of growth was higher than the average national level. Thus, in 1997–2001 the increase in the production of natural gas grew by 2 times, of petroleum and casing-head gas, by 1.7 times, and of ferrous and non-ferrous metallurgy, by 1.1 and 2.8 times respectively.

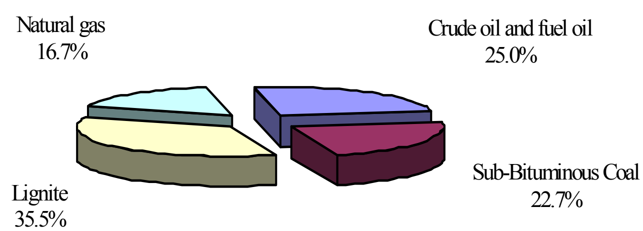
Over the past decade, the sectoral structure of the national economy has changed significantly. At present, out of total industrial production, the processing industry accounts for 46.9%; mining, 44.3%; and electric power, gas, and water production and distribution, 8.8%. In 1991, the biggest share of industrial production was found in machine building, light and food industries (more than half of the total volume); in the mid 1990s, the fuel industry – including petroleum production and refining, gas production and coal mining – reached 23.4%, and the share of the metallurgical industry was 25.1%. In 2002, these sectors combined represented 60% of industrial production.

Fuel Consumption Pattern. Essential information about fuel consumption in the Republic of Kazakhstan can be obtained from the national energy budget. Unfortunately, the time line of the initial data (types of fuel) used for the energy budget made by the Statistics Agency of the Republic of Kazakhstan is not homogeneous, as different methods have been used to gather data. Prior to 1990, energy budgets were compiled using the methods of the USSR. From 1991 to 1998 no energy budgets were compiled. During that period, the following documents were produced: a reference book, "Balance of Production and Distribution of the Basic Types of Raw Materials", which described production, import and export of some types of fuel resources, and the bulletin "On Residues, Receipt and Consumption of Fuel in the Republic of Kazakhstan", which described domestic consumption of fuel and energy resources by type of economic activity. In 1998 a consumption balance sheet was prepared for the first time as a part of the energy budget of the Republic of Kazakhstan.

In 1999, for the first time in Kazakhstan, methodological recommendations were developed for the compilation of the energy budget, comprising two major parts: Resources and Distribution. These methodological developments were based on long-term practical experience with national statistics and followed international statistical standards. Starting in 1998, fuel classification by type of activity was made in conformity with the statistical classification of the European Economic Community. The work was implemented under the "Program of Improvement of State Statistics of the Republic of Kazakhstan". In order to ensure compatibility of statistical information, in 1998 the Statistics Agency of the Republic of Kazakhstan adopted international standards. In 1999, a General Classification of All Types of Economic Activity (OKED) was introduced to replace the former Classification of National Economic Sectors (OKONH).

The structure of consumption of the main fuel types in the Republic of Kazakhstan is shown in *Figure I-1*, which shows that coal accounts for more than half of fuel consumed, 58.2%. Most is of low quality, with high ash content.

Figure I-1: *Fuel Consumption Structure in 2000 in Kazakhstan*



From Table I-1, which shows the consumption balance for all types of fuel in Kazakhstan in 2001, it can be seen that consumption of coal in Kazakhstan was about 50 million tonnes, of which less than 0.5% was used for non-power purposes.

Main Sources of Air Pollution. The main sources of air pollution in Kazakhstan are first of all the enterprises in the heat-and-power sector, in ferrous and non-ferrous metallurgy, in the oil-and-gas industry, and in road and rail transport. Among large enterprises, the Balkhash Mining and Metallurgical Plant is considered to be the largest polluter of the atmosphere (accounting for about 20% of all air pollution emissions in the Republic). Atmospheric transportation brings some polluting substances into Kazakhstan from neighbouring countries, and there is also transboundary transport of polluting substances to neighbouring countries from the territory of the Republic. For this reason, it is necessary to obtain accurate information about polluting substances emitted into the atmosphere in order to evaluate the environmental impact of industrial enterprises, calculate transboundary pollution flows and forecast air pollution.

Table I-1: *Fuel Consumption Balance in Kazakhstan in 2001, in thousand tonnes*

Fuel type	Production	Import	Export	Stock Change	Losses
Crude Oil	40088.0	2336.9	32400.5	1296.4	345.5
Gasoline		437.5	97.2	191.0	3.56
Jet kerosene		121.9		7.6	0.165
Gas/diesel Oil		447.7	333.5	196.3	5.117
Residual Fuel Oil		80.3	1000.4	175.9	1.533
Residual Fuel		0.358	133.4	1.9	0.007
CNG		11.0	360.1	10.4	1.469
LPG		68.4	3.8	1.74	
Bitumen	66.4	125.4		7.4	0.001
Lubricants	0.836	32.3	0.643	15.3	0.001
Petroleum Coke		0.01	92.1	15.3	
Other Oil		3.9	218.9	5.2	59.2
Sub-Bituminous Coal	75958.9	205.1	27244.2	672.1	495.9
Lignite	2680.1		268.2	-39.1	0.254
BKB & Patent Fuel	58.7			38.2	
Coke Oven/Gas Coke	2461.7	820.3	1.6	-30.7	0.009
Natural Gas (Dry), million m^3	8279.1	4279.5	5538.5	959.9	185.7
Solid Biomass, thousand m^3	121.9			11.66	

The volume of air pollution emissions is directly dependent on the industrial production level. Thus, the volume of polluting emissions from stationary sources in 2002 was 46% below the level of 1990, and 18.4% below the level of 1995. Emissions have grown since 1998. Although still lower than 1990 levels, since 1998 their increase was 8.6%. In 2002, the total of 1855.8 thousand tonnes of air pollution emissions were composed mainly of sulphurous anhydride, 61%, carbon monoxide, 20.3%, nitric oxide, 9.5%, and hydrocarbons 7.1% (not including volatile organic compounds, VOCs). In 2002, substantial amounts of substances extremely hazardous for human health were emitted into in the atmosphere of the Republic, among them hydrogen sulphide (1413.5 tonnes), ammonia (1849.3 tonnes), lead and its compounds (4857 tonnes), sulphuric acid (185.5 tonnes), arsenic (1081.5 tonnes), fluorine (50.5 tonnes), and mercury (0.7 tonnes). The growth of industrial production without related environmental protection measures and the immaturity of environmental policy, which is not able to encourage a reduction of air pollution emissions, can lead to a substantial worsening of the environmental situation in the country.

Convention on Long-Range Transboundary Air Pollution

The Convention on Long-Range Transboundary Air Pollution (CLRTAP, hereinafter also referred to as the Convention) was signed on November 30, 1970 under the aegis of the United Nations Economic Commission for Europe (UNECE). The Convention became the first international agreement acknowledging the existence of problems in the sphere of environmental protection and human health caused by the transboundary transport of atmospheric pollutants; it confirmed the need to resolve these problems at the regional and subsequently at the hemispheric levels. At present, the participants of the Convention, including Kazakhstan, comprise 49 of 55 member countries of UNECE.

The Republic of Kazakhstan joined the Convention on January 11, 2001, following Law of the Republic of Kazakhstan No 89 of October 23, 2000, "On Accession of the Republic of Kazakhstan to the Convention on Long-Range Transboundary Air Pollution".

The Convention is a framework document defining general commitments of the Parties in the following spheres: co-operation on the implementation of measures for the reduction of emissions causing transboundary pollution and the submission and exchange of related information.

In conformity with *Article 2* of the Convention, the Parties will strive to limit and as far as possible gradually reduce and prevent air pollution, including long-range transboundary air pollution.

Within the framework of the Convention, the Parties – supported by exchanges of information, consultations, research activities and monitoring – must develop policy and strategy measures to address pollution, taking into account existing efforts at national and international levels (*Article 3*).

The parties to the Convention exchange information and consider policies, scientific activities and technical measures aimed at reducing the emission of pollutants that can have negative impact, thus contributing to a reduction of air pollution including long-range transboundary air pollution (*Article 4*).

In accordance with *Article 9,* the Contracting Parties stress the need for the implementation of the Cooperative Programme for the Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) and, with regard to the further development of this Programme, agree to emphasize:

(a) The desirability of Contracting Parties joining in and fully implementing EMEP which, as a first step, is based on the monitoring of sulphur dioxide and related substances;

(b) The need to use comparable or standardized procedures for monitoring whenever possible;

(c) The desirability of basing the monitoring programme on the framework of both national and international programmes. The establishment of monitoring stations and the collection of data shall be carried out under the national jurisdiction of the country in which the monitoring stations are located;

(d) The desirability of establishing a framework for a cooperative environmental monitoring programme, based on and taking into account present and future national, sub-regional, regional and other international programmes;

(e) The need to exchange data on emissions at periods of time to be agreed upon, of agreed air pollutants, starting with sulphur dioxide, coming from grid-units of agreed size; or on the fluxes of agreed air pollutants, starting with sulphur dioxide, across national borders, at distances and at periods of time to be agreed upon. The method, including the model, used to determine the fluxes, as well as the method, including the model used to determine the transmission of air pollutants based on the emissions per grid-unit, shall be made available and periodically reviewed, in order to improve the methods and the models;

(f) Their willingness to continue the exchange and periodic updating of national data on total emissions of agreed air pollutants, starting with sulphur dioxide;

(g) The need to provide meteorological and physical-chemical data relating to processes during transmission;

(h) The need to monitor chemical components in other media such as water, soil and vegetation, as well as a similar monitoring programme to record effects on health and environment;
(i) The desirability of extending the national EMEP networks to make them operational for control and surveillance purposes.

EMEP focuses on such aspects as:

- environmental monitoring on the basis of both national as well as international programs;
- exchange of data on emissions and transboundary flows and the submission of models used for calculation of the latter;
- submission of meteorological and physical and chemical data related to atmospheric processes;
- monitoring of chemical components in other media as well as implementation of a similar monitoring program for the impact on human health and environment; and
- expansion of EMEP monitoring networks.

At present, special attention is being paid under EMEP to impacts on human health of pollutants such as fine particulate matter, tropospheric ozone, NO_2, persistent organic pollutants (POPs) and heavy metals. Much attention is also being given to issues as such damage inflicted by ozone to forests and agricultural crops, eutrophication of rivers, lakes and regional seas, as well as the complex impact of acidifying substances, heavy metals and POPs precipitation on soil, vegetation and water ecosystems, and their restoration in line with a reduction of emissions ("EMEP Strategy for 2000-2009" EB.AIR/GE.1/2000/5).

Specific measures to reduce pollution emissions are stipulated in the ***Protocols to the Convention***:

- Protocol on Long-Term Financing of the Co-operative Program for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP), 1984;
- Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent, 1985;
- Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes, 1988;
- Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes, 1991;
- Protocol on Further Reduction of Sulphur Emissions, 1994;
- Protocol on Heavy Metals, 1998;
- Protocol on Persistent Organic Pollutants, 1998;
- Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, 1999.

Co-operation with EMEP International Centres

Within the EMEP structure there are four Centres in operation:

- Chemical Coordinating Centre (CCC)
- Meteorological Synthesizing Centre - East (MSC-East)
- Meteorological Synthesizing Centre - West (MSC-West)
- Centre for Integrated Assessment Modelling (CIAM).

The *Chemical Coordinating Centre* has been based at the Atmospheric Air Research Institute of Norway since the beginning of the EMEP in 1979. The main objectives of the EMEP CCC consist in co-ordination of the EMEP Measurement Program, including:

- recommendation of methods to be used in the countries;
- control over methods used;
- quality control of measurements and training of specialists to ensure comparability of the results received in the field and in the laboratory;
- confirmation of data and reporting on data keeping.

The CCC also carries out EMEP work in the sphere of atmospheric particles.

The *Meteorological Synthesizing Centre "East" (MSC-East) (*Moscow, Russia) has operated as an EMEP international centre since 1979. Until 1995, MSC-East focused on assessments of the transboundary transmission of acidic components (SO_x and NO_x).

Starting in 1995, MSC-East has concentrated its activity on research and modelling of the long-range transmission of heavy metals and persistent organic pollutants (POPs), and it is responsible for development and use of mathematical models for heavy metal and POPs transmission. Pollution transmission modelling requires detailed knowledge of the mechanisms of release of heavy metals and persistent organic pollutants (POPs) into the atmosphere and the processes of their migration and accumulation in various natural media. In the basic models, an evaluation of regional, hemispheric, and intercontinental atmospheric transmission of heavy metals and POPs must be specified.

The *Meteorological Synthesizing Centre "West" (MSC-West)* has been based at the Atmospheric Air Research Institute of Norway since the beginning of EMEP in 1979. The main objective of EMEP MSC-West is modeling transboundary transmission of acidifying compounds, photo-chemical acidifiers and fine particulate matter.

Initially, the two-dimensional Lagrangian model was used for sulphur only, but later on components of nitrogen and tropospheric ozone were included. Currently, MSC-East operates with:

- the two-dimensional Lagrangian model for sulphur and nitrogen compounds as well as versions for photo-chemical acidifiers and ozone,
- the three-dimensional Euler model for sulphur and nitrogen compounds and photo-chemical acidifiers.

In 1999, the Executive body of the Convention on Long-Range Transboundary Air Pollution took a decision to include integrated assessment in the core activities of EMEP and to establish a *Centre for Integrated Assessment Modelling (CIAM)*. The activity of CIAM is related to analysis of scenarios for cost-effective reduction of acidification, eutrophication, tropospheric ozone and related phenomena, and especially fine particulate matter pollution. Modeling covers the following:

- abatement options for reducing emissions of SO2, NO_x, VOC, NH3 and fine particulate matter, including structural measures in the energy, transport and agricultural sectors, and their costs;
- projections of emissions, including the consequences of implementing current legislation;
- analyses of the environmental and health effects and the economic benefits of emission reduction.

The basic distribution of EMEP activities among its centres can be presented as follows:

- emissions database (MSC-West)
- monitoring (CCC); and
- modeling (MSC-East, MSC-West, CIAM).

In their activities, EMEP centres work in close co-operation among themselves. Other important partners for co-operation are:

- the Arctic Monitoring and Assessment Program (AMAP);
- the United Nations Environmental Program (UNEP);
- WMO's Global Atmosphere Watch Program (GAW/WMO);
- the Helsinki Commission for Baltic Marine Environment Protection (HELCOM);
- the Commission for the Protection of the Marine Environment of the North-East Atlantic (OSPAR);
- the International "Geosphere-Biosphere" Program (IGBP) and the International Global Atmospheric Chemistry Project (IGAC);
- the EUREKA Project to study the transport and chemical transformation of environmentally relevant trace constituents in the troposphere over Europe – second stage (EUROTRAC-2);
- the Clean Air for Europe (CAFÉ) Programme of the European Commission and the European Environmental Agency.

PART I. EMISSIONS INVENTORY

1. Review of the Existing Inventory System for Pollution Emissions in Kazakhstan

1.1. Regulatory and Legal Basis

Quality information about pollution emissions is needed for the following tasks:

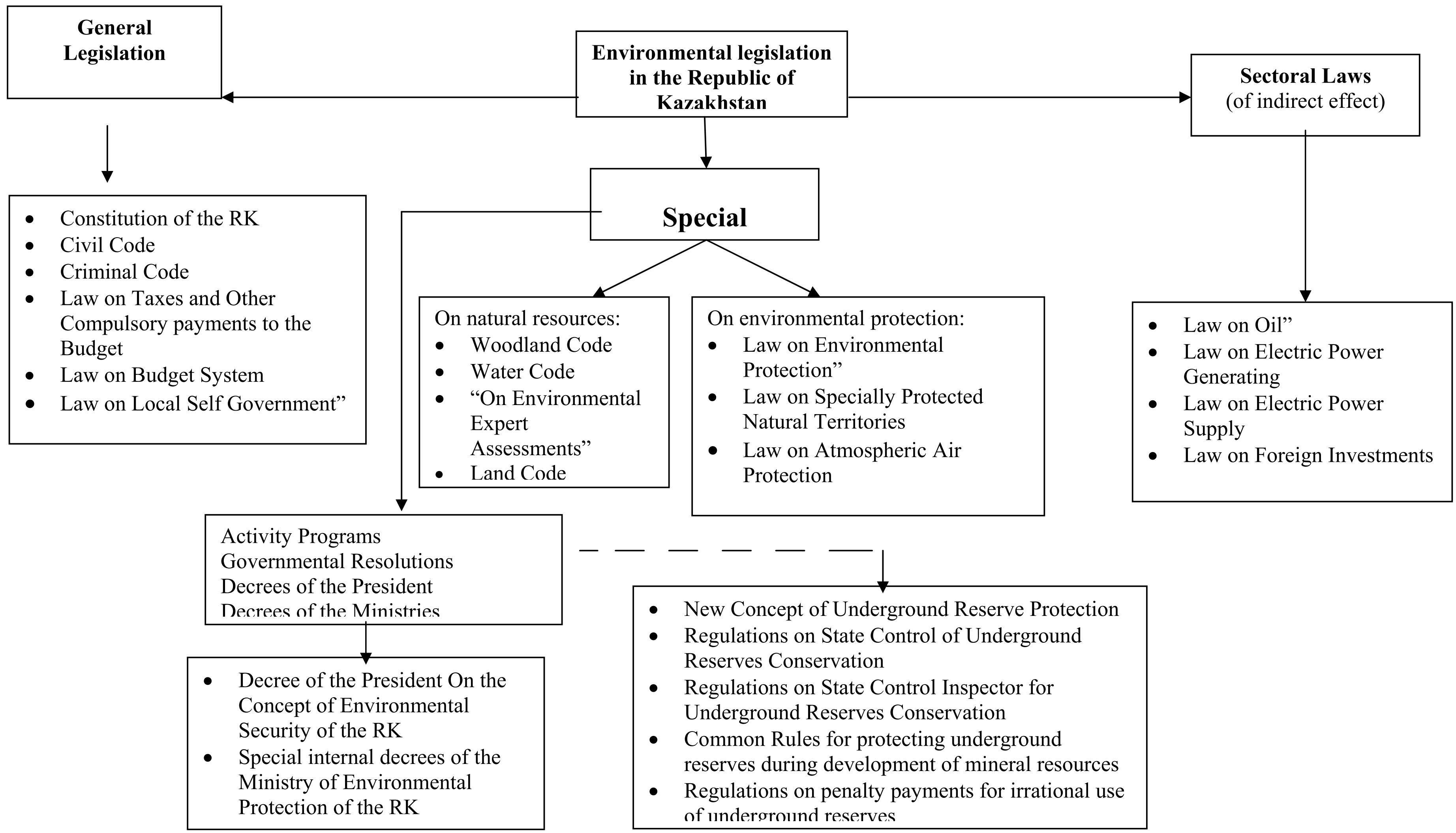
- meeting international reporting commitments and providing information for transboundary transmission modelling;
- monitoring pollutant levels at the national, regional, and local levels;
- assessing pollution impact on human beings, ecosystems, and infrastructure;
- managing (reducing) pollutants emissions into the environment; planning atmospheric protection and nature conservation measures;
- forecasting changes in the environment;
- strategic planning for the development of industrial sectors;
- pursuing environmental protection policies, also at international level;
- trading emission quotas, settling claims and other environmental conflicts.

Legislation is a foundation for the establishment of an effective system of state environmental protection (see *Figure I-2*). Environmental activity is stipulated as one of core objectives in the Constitution of the Republic of Kazakhstan of 1995, in Article 31. At present, a number of basic legislative acts have been adopted in Kazakhstan, regulating issues of state management in the sphere of environmental protection and natural resource utilisation. These include the Laws on Land, on Atmospheric Air Protection, the Water Code and others. Environmental policy isues were included in the Strategy for Development of Kazakhstan for the Period till 2030 and its constituent part – the Strategy entitled "Environment and Natural Resources – 2030".

The basic law regulating issues of information and state statistics in the sphere of environmental protection is Law № 160-I of the Republic of Kazakhstan, ***On Environmental Protection*** (July 15, 1997 with amendments and additions of June 4, 2001 № 205-II). Key sections of this law are as follows:

> **Chapter XIV**. Information and state statistics in the area of environmental protection.
>
> **Article 71.** Information in the area of environmental protection is information on the condition, pollution and improvement of the natural environment, on finance (sources of funding), on spending of funds on certain measures associated with the protection and rehabilitation of the natural environment, on the condition, reproduction and use of natural resources, impacts upon the natural environment, on established standards of its quality and environmental requirements for economic and other types of activity. It shall be open, public and subject to publication in the mass media. Officials shall be prohibited from concealing information and from presenting delayed or deliberately false information in the area of environmental protection.

Figure I-2: *System of Environmental Legislation in the Republic of Kazakhstan*



Article 72. State Statistics in the Area of Environmental Protection.

Specially authorised state bodies shall maintain state statistics in the area of environmental protection on the basis of objectivity of statistical information and its comparability with international statistics.

Legal entities and physical persons shall submit statistical information in accordance with the established volumes and within established time frames in the form of state statistical reports and at the expense of the sender of such information.

Minimum parameters of the state statistical reporting documents and procedures for maintaining state statistics in the area of environmental protection shall be defined in legislative and other normative legal acts of the Republic of Kazakhstan: № 98-1 "On State Statistics" of May 7, 1997 with amendments and additions made by the Law of the Republic of Kazakhstan № 280-II of 15.01.2002. This law specifies basic principles of collection, processing, and distribution of statistical data on phenomena and processes happening in the sphere of environment.

The state policy of the Republic of Kazakhstan in the field of statistics is aimed at the development and improvement of a common statistical informational system based on scientific methodology and international standards. Statistics policy is being built on the principle of uniformity of management within the system of primary registration and statistics. The number of state statistical observations is determined by the national government in its Statistical Work Plan and in the lists of forms used for national and sectoral statistical reporting.

The intensive development of the raw mineral industrial complex has resulted in the country's current industrial structure, heavily weighted in favour of the most environmentally hazardous sectors, such as energy, metallurgy, chemicals and petrochemicals. The predominance of extracting industries in Kazakhstan's economy requires state control over environmental conditions. The existing legal system for protection of the air is found in the Law on Atmospheric Air Protection, adopted on March 11, 2002. Norms and regulations that support environmental protection in general and air quality in particular are provided in acts of the President of the Republic of Kazakhstan, Parliament, Government and the central executive bodies of the Republic of Kazakhstan, in conformity with their competences as stipulated in the Constitution and legislation of the Republic.

There are also sectoral statistical and data collection systems, which often have specific sets of indices, problems to be resolved, organisational structure, and degree of automation of monitoring and data processing.

1.2. The State Reporting System for Atmospheric Air Protection

According to the Law on Atmospheric Air Protection (*Chapter 4, Article 20*), physical persons and legal entities that own sources creating air pollution emissions or other hazardous physical impacts on the atmosphere are to make an emission inventory regarding the polluting substances discharged and their sources. The enterprises are to report the inventory results. The requirements for report submission are determined by the central executive body of the Republic of Kazakhstan for environmental protection (the Ministry of Environmental Protection). Analytical agencies under the territorial administrations for environmental protection enforce enterprise compliance with regulations on maximum allowable emissions, toxicity of automotive emissions, and validity of data.

A standard statistical reporting format for polluting emissions is used, Form No. 2-TP (air), Report on Atmospheric Air Protection. The Statistics Agency of the Republic of Kazakhstan approves the form on an annual basis. The format has hardly changed from that used in the former Soviet Union.

On the basis of the primary information collected, the Statistics Agency of the Republic of Kazakhstan annually produces a consolidated report on the status of atmospheric air protection in the Republic of Kazakhstan: data on the country as a whole are included, as well as by oblast and oblast centre.

It can be concluded, based on an analysis of the existing reporting system on polluting emissions in Kazakhstan, that this system can be partially used for the submission of emissions information within the framework the Convention on Transboundary Air Pollution. It is based on a "bottom – up" approach, i.e. on data submitted by the enterprises.

The list of pollution parameters for enterprise reporting is determined annually with the Ministry of Environmental Protection of the Republic of Kazakhstan, and if required the reporting format can be amended or supplemented.

Statistics on air pollution are made using reporting from all enterprises that have stationary sources of the air pollution, regardless of their total emissions and whether or not they are equipped with pollution control facilities. Statistics are compiled twice a year, for the semi-annual period and for the whole year.

The data requested in form No. 2-TP (air), Report on Atmospheric Air Protection, include the following:

- the emission sources;
- the discharge of pollutants without pollution control equipment ('in total' as well as 'by ingredient');
- quantity of pollutants arriving at pollution abatement facilities (in total as well as by component);
- quantity of pollutants abated (in total as well as by component);
- quantity of pollutants emitted into the atmosphere;
- norms established for pollutant emissions (maximum allowable emissions, temporarily agreed emissions);
- emissions of specific pollutants into the atmosphere;
- measures implemented to reduce emissions into the atmosphere.

Reporting under form No. 2-TP (air) is to be based on primary data from monitoring carried out at the enterprises, on the rosters registering stationary pollution sources and their characteristics, on the rosters of measures taken for air protection, the rosters of operational maintenance for gas-purifying and dust-collecting facilities, as well as the environmental passports of the enterprises.

The statistics bodies have defined technical procedures for the collection and processing of the data. The procedures for the collection of reporting materials consist of the following:

1. A list of reporting enterprises (a catalogue of enterprises) is drawn up, based on the statistical register of the enterprises, and is agreed with the oblast environmental protection administrations. The catalogue of the enterprises contains brief

administrative and economic information on legal entities and their divisional units;

2. The approved blank forms for reporting – form No. 2-TP (air) – together with guidelines on filling out the form are sent to the enterprises and their divisional units;
3. The compiled forms are submitted by the enterprises to the oblast environmental protection administration for compulsory review;
4. The agreed forms, approved by seal, are sent to the oblast statistics administration;
5. The oblast statistics administration compiles the reporting forms, in accordance with the agreed catalogue of the enterprises;
6. Once collected, data are automatically input, controlled and processed;
7. For arithmetic or logical mistakes in reporting, an inquiry is made to a relevant enterprise and verification of the information is carried out;
8. After having made corrections, consolidated results are prepared at the oblast level;
9. The consolidated oblast information is classified by district (*rayon*), by the most polluted city and industrial centre, and by type of economic activity;
10. The resulting primary oblast information is sent by modem transmission to the Statistics Agency of the Republic of Kazakhstan;
11. Based on the collected primary information, the Statistics Agency of the Republic of Kazakhstan makes up a consolidated annual report on the status of atmospheric air protection. The consolidated statistical data are classified by oblast, by most polluted city and industrial centre, and by type of economic activity;
12. Starting in 1998, an Information Database containing data on ambient air pollution from stationary sources was instituted in the Republic.

Using reporting results, statistical bulletins are prepared, published and sent to all the governmental bodies – the Administration of the President, Chancellery of the Prime Minister, Senate and Majilis of the Parliament, interested ministries and government departments.

It should be noted that in the reporting form, data on mobile sources, including road transport, are not requested.

1.3. The State Statistical Reporting Form No. 2-TP (air)

Registration of the volumes of pollutants by enterprises and in total by all industrial actors of Kazakhstan is carried out using the state statistical reporting form 2-TP (air) on semi-annual basis (as approved by Order № 19-П of the Republican Statistics Committee, July 5, 2002). The state statistical reporting form is compiled by enterprises, organisations, partnerships, joint stock companies, etc. (hereinafter all referred to as enterprises) – i.e. by all economic entities, regardless of their form of ownership, that have stationary sources of air pollution emissions. The form is compiled by all enterprises regardless of their gross volume of emissions. The report is signed by the head of the enterprise, and it must be approved by the oblast territorial administrations of environmental protection.

All polluting substances present in emitted gases should be registered and inventoried, with the exception of substances used as raw materials in other technological processes (for example, carbon monoxide contained in the metallurgical waste gas at ferrous metallurgy enterprises can be used as a raw material). The amount of pollutants emitted over a reporting period (total, hard, gaseous, and liquid substances as well as by ingredient) is stated on the basis of calculations or of instrumental measurements performed during the period of inventory.

The reporting form 2-TP (air) has *four sections*:

Section 1. Polluting Emissions into the Atmosphere, their Abatement and Utilisation.

Section 2. Emissions of Specific Pollutants into the Atmosphere.

Section 3. Sources of Polluting Emissions into the Atmosphere.

Section 4. Measures Taken to Reduce Polluting Emissions into the Atmosphere.

In the *First Section,* the magnitude of polluting emissions into the atmosphere is requested, as well as information about their abatement or utilisation. Following this, the amount of substances from all stationary sources emitted after abatement facilities is shown. Then, the amount of pollutants abated is indicated. Further on, the total quantity of pollutants emitted into the atmosphere (total, including solid, gaseous, and liquid substances as well as by ingredient) is shown aggregately, including substances after abatement as well as those emitted without abatement. In addition, in order to control observance of the established maximum allowable emission rates at the enterprise, this section also calls for maximum allowable emission values for each substance. All the data are shown in tonnes. Values for solids are shown in total, whereas for liquid and gaseous substances the figures are given by main polluting ingredient: sulphur dioxide, hydrogen sulphide, carbon monoxide, nitric oxides (converted to nitric dioxide values), ammonia, hydrocarbons (aggregately, without volatile organic compounds), volatile organic compounds separately and halogenated lead compounds within these.

In the *Second Section,* emissions volumes of a number of specific pollutants are requested separately: these are not included in the First Section: for example, heavy metals (mercury, cadmium, etc.), solid hydrocarbons, such as benz(a)pyrene, substances such as aerosols of sulphuric and nitric acids, and others. With this, the emissions of these substances into the atmosphere are shown directly and the values of the approved maximum allowable emission values are also shown for the purposes of comparison.

The *Third Section* is designed to help enforce observance of the norms of maximum allowable emissions into the atmosphere. In particular, this section requests the number of sources where maximum allowable emissions values have been reached and have not been reached, the number of sources equipped and those requiring equipment with abatement facilities, and a comparison of reported (actual) emissions by source with those permitted by the Ministry of Environmental Protection for the current year.

In the *Fourth Section,* the results of measures aimed at reducing hazardous substances emitted into the atmosphere for the reported year are shown. Among these, there are measures set by state programs, prescribed by state controlling organisations, or scheduled by the enterprises themselves. For example, in this section the following groups of measures are shown:

- improvement of technological processes resulting in reduction of polluting emissions;

- start-up of new abatement installations and facilities;
- increased efficiency of existing abatement facilities;
- elimination of pollution sources (closure of sectors of the enterprise or their restructuring for different types of production).

This section requests details on all measures, with no exception planned for the reported year. In the relevant table ranges and lines, completion and implementation costs are shown, or non-completion and the reasons why. In addition, the estimated annual reduction of emissions for the given measure is to be indicated starting, and the reduction of emissions for the current year achieved *de facto* (if, for example, the measure was accomplished at the beginning or in the middle of the year). Thus, the completed state statistical reporting form describes all the air-protection activities of the enterprise and aggregated data provides a total emission inventory across all enterprises of Kazakhstan.

2. Inventory Methods for Pollution Emissions

2.1. Inventory Methods for Pollution Emissions in Kazakhstan

2.1.1. General Requirements in Kazakhstan for the Inventory of Pollution Emissions into the Atmosphere

All currently operating enterprises and organisations carry out an inventory of polluting (hazardous) emissions in conformity with Article 20 of the Law of the Republic of Kazakhstan on Atmospheric Air Protection. This article is new compared to the previously effective Law of the Kazakh Soviet Socialist Republic on Atmospheric Air Protection.

An inventory of sources of air pollution emissions is the first stage in the development of the draft Normative Standards for Maximum Allowable Emissions, that is, the first stage in the creation of a regulatory base to control emissions at an enterprise. Inventory data should be approved by the enterprise itself and agreed with the local bodies of the Ministry of Environmental Protection of the Republic of Kazakhstan, i.e. the oblast territorial administrations for environmental protection.

The inventory procedure is specified in the Guidelines for Carrying out an Inventory of Hazardous Polluting Emissions into the Atmosphere, approved by the Ministry of Natural Resources and Environmental Protection on December 21, 2000 (516-P).

Under these Guidelines, the main objective of the inventory is *to obtain primary data* for the following purposes:

- assessment of the impact of an enterprise's hazardous polluting emissions on the environment (ambient air);
- establishment of the maximum allowable norms for emissions of hazardous substances into the atmosphere by the enterprise in general, as well as by separate sources of air pollution;
- organisation of enforcement of the established norms for emissions of hazardous substances;
- assessment of the condition of dust-collecting and gas-purifying equipment at the enterprise;
- evaluation of the environmental characteristics of the technological processes used at the enterprise;
- assessment of the efficiency of utilisation of raw materials and waste at the enterprise;
- planning of air protection activities at the enterprise.

The following concepts are used during the inventory process:

A hazardous substances emissions source is a unit where hazardous substances are formed (a technological installation, machinery, apparatus, warehouse of raw materials or finished products, open space for handling/reloading of raw materials or finished products, capacities for storing fuel, dumping grounds for industrial and household waste, etc.);

A source of atmospheric pollution is a unit from which polluting substances are emitted into the atmosphere;

Organised emissions of hazardous substances are emissions discharged through specially constructed installations;

Unorganised emissions of hazardous substances are emissions discharged as unmanaged streams of gas: for example, as a result of a seal failure on equipment, lack of or insufficient gas suction equipment at product loading, unloading or storage sites, in dust dumps, etc.

Methodological guidance for carrying out enterprise emission inventories is provided by the local bodies of the Ministry of Environmental Protection, i.e. by the oblast environmental protection administrations.

In the course of its emissions inventory, the enterprise is to account for all the hazardous substances emitted into the atmosphere present in the material balance sheet of the applied technological processes, from all stationary polluting sources (organised as well as unorganised) at the enterprise, and from motor transport. The selection of inventory methods depends first of all on the type of industry and the type of source. Instrument measurements are basically required for sources with organised emissions. Such sources include the following:

chimneys and ventilation pipes;

ventilation shafts;

aeration lanterns;

deflectors.

Calculation methods are mainly applied to unorganised sources, which include:

loose and leaking equipment;

loading and unloading operations;

open storage of raw materials;

equipment and technological processes located in open areas (movable welding posts, storage reservoirs for mineral oil and oil products, oil traps, open evaporation surfaces, etc.);

blasting activities;

open parking spaces for cars.

For the calculations, the techniques applied are to be agreed with the central executive body (currently the Ministry of Environmental Protection of the Republic of Kazakhstan).

Enterprise-level emission inventory work includes the following stages:

1. preparatory work;
2. inventory research;
3. processing of inventory research results and formulation of final material.

In the *first stage,* a brief overview is compiled for the enterprise as a source of atmosphere pollution, including balance schemes and descriptions of basic technological processes. Together with this, hazardous substances emitted and their sources must be defined. The balance schemes must be compiled in conformity with the norms of technological design for the relevant industry.

At the *second stage,* an investigation is made of the sources of polluting emissions, as well as the efficiency of dust-collecting and gas-purifying equipment and their specifications.

At the *third stage,* the results obtained are organised and analysed, the blank inventory forms are filled in, and the list of methods used to define concentrations and to calculate emissions of hazardous substances is compiled.

After having analysed the inventory materials, the local body of the Ministry of Environmental Protection (i.e. the oblast environmental protection administration) submits the following documents to the enterprise:

- the list of hazardous substances to be subject to state registration, by which the enterprise organises its primary enrolment;
- the list of hazardous substances for which the enterprise is to submit annual reports using form 2-TP (air).

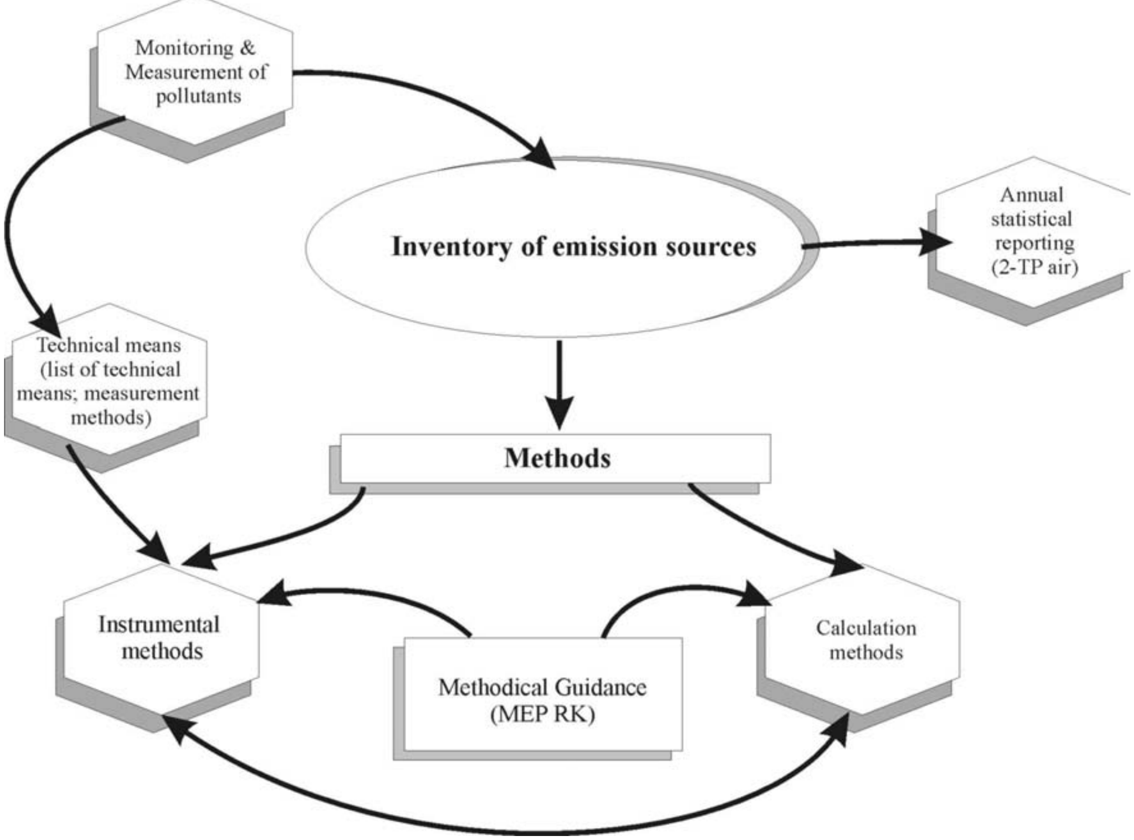
The primary enrolment of polluting sources is carried out in the "Roster for Registration of Stationary Sources of Pollution and their Characteristics", using form POD-1. The entries in the roster under form POD-1 are done on the basis of and in proportion to the inventory process. The following information is registered in the roster: number of polluting sources, emission rates for each pollutant (g/sec), by each polluting source, time of operation of the source (hours/days), amounts of substances abated (g/sec) and their percentage (%), and method for defining the mass of emitted substances. On the grounds of the entries in the roster, statistic reporting form 2-TP (air) is filled out by the end of the year.

The organisation of the emission inventory at the enterprises of Kazakhstan involves making the following choices:

- method of work;
- methods for the calculation of the magnitude of emissions, or instruments or equipment for instrumental measurement of the composition of polluting substances;
- control methods for inventory results.

The method for inventory work is defined at the first preparatory stage, when inspection of the enterprise is carried out and a list of polluting sources is compiled. Depending on the method chosen, the techniques for the calculation of pollution levels or the devices and equipment for their direct measurement are selected. The Ministry of Environmental Protection of the Republic of Kazakhstan must approve the techniques for calculation of emissions. The devices and equipment as well as measurement techniques must be included in the relevant rosters of the State Standards Committee of Kazakhstan (Gosstandard). The accuracy of the inventory data is controlled using measurements at the sources or in monitoring measurements of the content of pollutants in the ambient air. The list of the sources under control and of the composition of polluting substances by ingredient is compiled by the enterprise on the basis of recommendations from the oblast territorial administration of environmental protection. In case the control values of measurements at the sources and in the atmosphere are different from the inventory data, the inventory process is to repeated to verify the emission values of the instrumental measurements with regards to the sources and ingredients questioned. The scheme for undertaking emission inventories of enterprises in Kazakhstan is shown at *Figure I-3*. The responsibility for completeness and authenticity of the inventory data rests with the head of the enterprise.

Figure I-3: *Organisation of Emissions Inventories of Enterprises in Kazakhstan*



2.1.2. Calculation Methods for Determining the Magnitude of Pollution Emissions

When using the calculation methods, pollution emission values are defined based on formulas specified in the relevant methodological guidelines. Together with these formulas, different modes of operation of the equipment, work areas and production sectors are taken into account, including different stages of multi-staged technological processes. As a rule, the calculation methods only use one value of a specific emission of a substance: the average value in relation to the unit of raw material, finished material, operating time of the equipment, etc. As a rule, this value is determined by experiments, using numerous measurements and comparisons with the theoretically possible discharge of pollutants according to the technological performance of the equipment. In order to set a single approach for the determination of emissions, and also take into account the various production processes at different enterprises, the booklet "Set of Methods for Calculation of Polluting Emissions into the Atmosphere by Different Industries" was developed in the Republic of Kazakhstan. This is a basic methodological manual for the determination of enterprise emissions.

The formulas specified in the "Set of Methods" are used for the determination of emissions from the following industrial processes:

- fuel combustion in boilers with a production capacity under 30 tonnes of steam per hour;
- machine building and metal processing;

– loading-unloading operations and storage of petroleum and oil products;
– production of oil products;
– production of tires and industrial rubber products;
– wood processing;
– extraction and processing of coal.

For the calculation of emissions in industries not included into the “Set of Methods”, other methods are used that take into account specific production processes. Thus, for the determination of emissions in civil engineering, the booklet entitled “Methodological Recommendations for Calculation of Polluting Emissions into the Atmosphere by the Civil Engineering Enterprises” is used. For calculation of emissions from diesel installations, the booklet of “Recommendations for Calculation of Polluting Emissions from Stationary Diesel Installations” is applied. For the Republic’s highly developed oil-and-gas industry, the methods for determining pollution emissions from installations for the collection, preparation and transportation of petroleum and gas as well as emissions from flares are of great importance. These methods are defined in “Methods for Calculation of Unorganised Emissions from Gas Processing Installations”, “Methods for Determination of Gross Emissions from the Hydrocarbon Burning Flares” and other sources.

Here is a description of basic methods for the calculation of emissions from the most common industries. Determination of emissions using sectoral methods is based on the peculiarities of different production processes. Thus, the *calculation of emissions from heat-and-energy entities* is based on data characterising the type of fuel and the process of combustion in a particular boiler. With the help of specific coefficients and parameters characterising the fuel and the combustion process, the following polluting substances can be determined: nitric dioxide (NO_2); nitric monoxide (NO); sulphur dioxide (SO_2); solid fuel ashes (if coal is used as a fuel); fuel oil ashes (if fuel oil is used as fuel or for kindling); carbon monoxide (CO); and soot (C), for small water boilers with production capacity under 30 tonnes of steam per hour. For the calculation of emissions the following is to be taken into account: total hourly and yearly consumption of fuel (value B), ash content of the fuel per working mass (value A^r), share of solid particles captured in the ash trap (value ŋ), content of inflammable substances in the fuel (value Γ), content of sulphur in the fuel per working mass (value S^r), heat from burning natural fuel (value Q^r), quantity of carbon and nitric oxides discharged per unit of heat (values K_{co} and K_{NOx}), ratio of air surplus (value λ). A part of the required information, characterising the properties of the given type of fuel, is obtained from its certificate (ash-content, sulphur content, content of inflammable substances, heat from burning, etc.); another part is determined during the inventory of sources directly from observation of the given water boiler (share of solid particles captured in the ash trap, ratio of air surplus, etc.). Thus, by combining the characteristics of a given fuel with the method of its combustion in specific equipment, the magnitude of emissions is calculated in making the inventory of heat-and-energy sources.

When determining emissions from machine-building and metal-processing enterprises, the following parameters are mainly used: specific discharge of polluting substance per unit of production (kg per tonne of produce - value q); production capacity of installations (value D), as well as efficiency of measures applied for the reduction of emissions (cyclones, scrubbers, settling chambers, other apparatus). Thus, the following emissions are determined from metallurgical and metal-processing processes:

- for smelting non-ferrous and ferrous metals – emissions of solid particles (dust), carbon monoxide (CO), sulphur dioxide (SO_2); hydrocarbons (C_xH_y), nitric dioxide (NO_2), nitric monoxide (NO); cyanides, fluorides (HF). If aluminium alloys are produced, also aluminium oxide (Al_2O_3) and silicon dioxide (SiO_2);
- for mechanical processing of metal – metallic dust, aerosols of industrial oil, self-emulsifying oil.

In the sectors of paint-and-varnish coating, emissions are determined on the basis of the amount of paint used for coating (value m_k), the share of paint lost in the form of aerosols during drying (value δa), the share of its volatile part (solvent) in the paint-and-varnish material (value fp), the share of solvent separated during coating (value δp). In addition, the method of coating is taken into account (pneumatic, airless, hydro-electrostatic, etc.). These are the ways of determining emissions of hydrocarbons (C_xH_y).

For emissions during uploading-unloading operations and storage of petroleum and oil products, hydrocarbons of different composition (C_xH_y) are discharged into the atmosphere. For calculation of their magnitude, it is necessary to establish the following: the volumes of liquid substance uploaded (unloaded, stored) in reservoirs during the year (value $U_ж$), the molecular mass of vapour of the liquid substance (value $M_п$), the adjusting coefficients (K) based on vapour pressure at 38 °C (value $P_{S(38)}$) and the temperature of gas space (value t_r), the adjusting coefficients (K) based on annual turnover of the reservoirs and the rate of their operation; the coefficient of efficiency of gas-trapping installations (value η).

For manufacturing petroleum products, first of all the amounts of emissions from oil heating furnaces are calculated similarly to the calculation of burning fuel in boilers. With this, the following emissions are determined: nitric dioxide (NO_2); nitric monoxide (NO); sulphur dioxide (SO_2); hydrocarbons (C_xH_y); soot (C). Second, the amount of pollutants from equipment used for manufacturing petroleum products is defined. With this, the magnitude of emissions is calculated basing on the volumes of hydrocarbon blends passing through a specific installation (value B), the composition of different fractions produced by the given installation (value q_f), the thermal coefficient accounting for temperature within the installation (value t), the pressure within the installation (value P). The composition of emissions by ingredient is designated as hydrocarbons (C_xH_y) and hydrogen sulphide (if hydrogen sulphide is present in the initial raw material).

To calculate emissions from tire and industrial rubber production, specific values of polluting discharges are used for each sector depending on their designation. In case of the operation of various types of equipment of different productivities, the data on quantity of substances discharged in a time unit, per unit of area or unit of produce are used. With this, the following substances are determined: solid components (soot), phenols, formaldehyde, ammonia, hydrocarbons (from petrol), carbon monoxide, vapours of rubber blends, and peptising agents (styrene, isoprene, nitrite, chloroprene, and others).

The calculation of emissions from the sources of wood processing enterprises takes into account the specific technological processes for wood working, manufacturing of glues, and preparation and varnishing of wood articles. With these processes, calculations are made for wood dust emissions, vapours of formaldehyde, phenol, ammonia, vapours of organic solvents, varnishes and enamels (xylol, toluene, acetone, butyl acetate, ethanol, and others). For the calculation of volatile components, data are required on the hourly consumption of organic solvents or resin-containing substances (value Q), the content of volatile components in the composition of glue or varnish (value φ), as well as the coefficient accounting for the relative amount of formaldehyde and phenol (for these ingredients only) discharged into the atmosphere in case of the application of one or another type of glue. For calculations of wood dust, data on the volumes of processed materials (value U) are required, as well as the specific weight of the processed material (value γ), the amounts of waste determined from the volume of initial raw material (value K_o), the coefficient of efficiency of local ventilation facilities (value K), the coefficient of dust formation depending on the method of processing of wood (value $K_п$), and the coefficient of efficiency of dust trapping equipment, such as different types of ventilators mounted on wood processing machinery (value η).

Calculations of emissions from coal extracting enterprises take into account the technological processes: drilling, blasting, and uploading-unloading activities, storage of coal at warehouses, concentration of coal, formation of rock dumping sites. With these elements, emissions of dust, carbon monoxides and nitric monoxides (including gaseous ingredients are discharged into the atmosphere at blasting) are calculated.

The amounts of dust discharged at *drilling operations* are calculated on the basis of the velocity of drilling (value $U_б$), the diameter of drilling wells (value d), the density of rock or coal (value ρ), the annual number of working hours (value T), the efficiency of dust-trapping devices (value η), the content of the dust fraction in drilling cuttings (value B), and the share of dust transformed into aerosol (value K_7).

For blasting operations, the following are calculated: emissions of dust, carbon monoxides and nitric monoxides, based on the specific discharge of polluting substances for each tonne of explosive materials (value $q_{уд}$), the amount of explosive materials used (value A), the coefficient of gravitational settling of polluting substances within the borders of the cavity (value K), and the efficiency of dust suppression means (value η).

In the case of unloading-uploading operations, the amount of solid particles emitted into the atmosphere is determined on the basis of the calculation of the specific emissions of polluting substances from a tonne of uploaded (re-loaded) coal (value $q_{уд}$), the annual quantity of uploaded (re-loaded) coal, a coefficient accounting for the water content of the material (value K_o), and coefficients accounting for local conditions: the value of the most common wind speed for the given locality (value K_1), degree of protection of sites for uploading (re-loading) activities from external impacts (value K_5), efficiency of application of the dust suppression means (value η). Where conveyer belts are used for unloading-uploading operations, the length and width of the conveyer belt is to be taken into account (values L and I), and also the coefficient of rock grinding (value γ).

For calculating dust from storage of coal, the total amount of coal arriving at the warehouse (value M_p) is taken into account, as well as all the coefficients and parameters listed for the calculation of emissions during unloading operations. For the calculation of dust forming during storage, the area of site is taken into account (value S_o), and also a coefficient accounting for the period of operation of storage (value K_2), and the annual number of days with steady snow coating (value T_c).

For emissions from coal at processing sites, dust discharges are calculated on the basis of the specific dust emission from one working plant (value $q_{уд}$), the quantity of annually processed coal (value Q), the number of plants working in the factory (value n), and the degree of efficiency of purification systems installed at the factory (value η).

The methodological recommendations for *calculating emissions into the atmosphere by the enterprises of civil engineering* are designed for the determination of emissions during the extraction of construction materials in open quarries, from drilling, blasting and uploading-unloading operations; for processing non-ferrous materials from crushing-and-sorting sites; and for the production of artificial porous materials. Calculation of emissions from drilling-and-blasting and uploading-unloading operations is performed similar to the methods described above for extraction works in the coal mining sector. The following is to be taken into account: the quantity of drilling machines, the specific emission of dust from operation of one machine, the quantity of material discharged into the air in the explosion of one kg of explosives, coefficients defining the share of dust in the rock, the share of dust transformable into aerosol, coefficients accounting for the speed of wind in the zone of operation, the quantity of processed rock, the conditions of development of the open quarry, etc. From crushing-and-sorting sites, the calculation of dust emission rates is made on the basis of specific indices of dust emission from uploading-unloading parts of crushing equipment, as well as the total annual productivity of this equipment.

Calculation of emissions from standard diesel installations is based on the application of the specific norms for the discharge of polluting agent per kg of fuel used (value q), the total consumption of fuel (value B), and the time of operation of the diesel installation (value T). The emissions calculated are those of carbon monoxide, hydrocarbons, sulphur dioxide, nitric monoxide, and nitric dioxide.

The methods of calculation of unorganised emissions from gas processing installations estimates emissions of hydrocarbons discharged through leaks. Together with this, the following is to be taken into account: the quantity of nod and sliding bars (value A), the percentage of received leakages (value k), the specific emission of polluting substances discharged through loose nods (value q), and the duration of operation of the equipment (value T).

The methods of determining *gross emissions from hydrocarbon blend flares* estimate the volume of emissions during flares. Based on this, emissions of the following pollutants are calculated: carbon monoxide, hydrocarbons, sulphur dioxide, nitric monoxide, nitric dioxide and soot. The magnitude of emissions is calculated on the basis of the composition of the blend flared, its content of hydrogen sulphide, combustion temperature (value To), the lowest heat of condensate combustion (value $q_{НК}$,), the coefficient of surplus air (value α), the combustion time (value τ), the completeness of condensate combustion (value n) and a number of other parameters characterising the process of combustion at a given flare.

As one can see from the brief description of calculation methods used in Kazakhstan, the magnitude of emissions from a given facility is determined not only using specific indices, but also taking into account the specific operating conditions of the types of equipment (or of the technological installation or process), as well as the local natural and other conditions related to location of the facility. These additional data are verified during the inspection of the enterprises and allow for rather realistic emission values for a specific industrial facility due to the versatility of the methods used.

From the above review, one can see that in Kazakhstan, methods for the calculation of heavy metal and persistent organic pollutants (POPs) emissions are practically not used. POP emissions in Kazakhstan at present are not calculated. As the developers of sectoral methods have stated, heavy metals are not singled out but are included among solid substances, i.e. dust. Thus, for the calculation of emissions from heat-and-energy installations, only ash is recorded, whereas a number of heavy metals should be calculated as well. Controls of the level of soil pollution in ash dumping grounds includes assessment of heavy metals: this proves the considerable content of heavy metals in ash. For example, in fuel oil ash, calculations are based on the content of vanadium, though there are other metals as well. Only total air emissions of solid particles (dust) are calculated across non-ferrous and ferrous metallurgy enterprises, and there are no reliable methods to calculate emissions of heavy metals at enterprises of this industry. Heavy metal emissions can be calculated using the so-called balance-sheet method: based on the content of metal in ore and its content in solid waste (slag, etc.) as well as the total dust content in the gas-air blend at each source, the discharge of metals into the atmosphere can be calculated. However, this method has a substantial error factor; most probably it can be used as a first approximation for the assessment of heavy metal emissions for reporting under the Convention.

Practically all the methods used for the calculation of emissions in Kazakhstan were developed by the sectoral research institutes of the former Soviet Union. For example, the methods for the calculation of emissions from heat-and-energy sources were developed at the Dzerzhynski Technological Institute (Balashikha, Moscow Oblast), those for oil extraction and refining sources, at the Ufa Institutes working on petroleum and gas, and so on. There are practically no Kazakh-developed methods. In the practical calculations related to emissions in Kazakhstan, re-printed and re-approved former Soviet methods are adjusted to local conditions, using emission coefficients.

2.1.3. Analysis of Methods for Instrumental Measurement of Polluting Substance Content in Industrial Emissions

The process of instrumental measurement of the content of polluting substances in emissions can be divided into the following stages:

- taking samples from the waste gas conduit;
- sample transportation;
- preparation of samples for analysis;
- measuring parameters of gas streams in gas conduits;
- measuring concentrations of polluting substances.

The samples of gases taken from waste gas conduits are usually taken in flows with high temperature, humidity, dust content, and corrosive chemical properties. Due to this, special devices are used for taking and preparing samples for analysis, as well as their transportation to the location for analytical control (analysis). The following devices are used: sampling borers, filtering elements, mechanisms for cooling, storing and transportation of a sample, as well as means for the aspiration of samples.

Sampling borers are devices which are used to take samples; a borer is made of rust-resistant steel with a diameter of 10-30 mm and length of 0.5-2.5 m. The primary purification of gas from dust is carried out with the help of a metal-ceramic filter mounted on the borer or on the inner side of a gas conduit. Fibreglass or fibre filters are used as filtering materials.

During transportation of the samples from the hot gas flows, the temperature of the sample is maintained above the dew point in order to prevent condensation that can include readily soluble pollutants. In this case, heated sampling pipes are used: these devices maintain the temperature of the gas up to 2000C. Power is supplied using an alternating single-phase electric current of 220 W. Cooling pipes can also be used, depending on the temperature required for the filter.

The *devices for cooling samples* are refrigerators of different types. The means of *sample aspiration* are boosters for gas consumption. They assure a supply of gas from the point of sampling to a primary measuring converter and create the drop in pressure required for overcoming the pneumatic resistance of the sampling devices. For analysis of the composition of a gas blend, a number of physical and chemical methods of analysis are used. The most widespread ones are electro-chemical, optical, chromatographic and plasmo- ionisation methods.

The methods listed are made with measurement devices (different types of automatic gas-analysing equipment), as well as with instrumental-laboratory methods of determining polluting substances in gas-air blends.

Technical Devices for Measurement. The technical devices allow direct measurements of the polluting content in a stream of gas. At present on the Kazakhstan market it is possible to buy different types of automatic gas-analysing equipment that make different types of measurements across specific ranges of polluting concentrations. Below, the most common devices are described: these are examples of devices made by Russian producers.

GIAM Optical-acoustic gas analysers. These gas analysers are designed for determining concentrations of carbon monoxide (CO); sulphur dioxide (SO_2); nitric dioxide (NO_2); nitric monoxide (NO), and hydrocarbons (by methane, CH_4) in waste gas streams with the following parameters: temperature not exceeding +3000 °C, humidity up to 240 g/m^3, dust content up to 40 g/m^3, pressure 3.9 - 4.4 kPa, velocity of the stream up to 40 m/sec. The concentration limits for measurement are as follows:

Substance:	**CO**	**NO**	**NO_2**	**SO_2**	**CH_4**
Concentration, g/m^3	≤ 15.0	≤ 2.0	≤ 0.1	≤ 6.0	≤ 1.0

A gas analyser is a stationary automatic device based on the optical-acoustic method of measurement and is built using a differential double-beam design. One chamber is for measurement: the gas bend under analyses is pumped through it. The second chamber is for comparison: it is filled with a gas that does not absorb infrared radiation. Heat radiators made with Ni-Cr alloy spiral are used as the source of infrared radiation.

INO2 Plasmo-ionisation gas analyser. This gas analyser is designed for determining concentrations of hydrocarbons (C_xH_y) at the following operation conditions: temperature not exceeding +150 °C, humidity up to 90 %, dust content up to 10 mg/m^3, atmospheric pressure 631 to 800 mmHg. The range of measurement of concentrations of C_xH_y is from 0 to 250 mg/m^3. The method is based on the measurement of the ionisation current created during the introduction of organic substances into the hydrogen flame. The method is highly sensitive to organic substances and is not sensitive to mixtures of inorganic origin.

Chemi-luminescence gas analyser of HLO2 type. This gas analyser is designed for determining the groups of nitric monoxide (NO) and nitric dioxide (NO_2). The method is based on the reaction of nitric oxides with excess ozone. This reaction shows a glow of a certain chemi-luminescence whose intensity is proportional to the content of NO in the stream of the received gas. This method is applicable for the determination of the concentration of NO_2 as well as NO, by reducing it with special catalysts. The blend parameters are as follows: temperature not exceeding +50 °C, humidity up to 35 g/м^3, dust content up to 5 mg/m^3, pressure 10-50 kPa. The range of measurement: 0 - 0.02; 0 - 0.05; and 0-0.15 % of the volume.

FA01 Photo-absorption gas analyser. This gas analyser is designed for the determination of concentrations of carbon monoxide (CO), sulphur dioxide (SO_2), nitric dioxide (NO_2), nitric monoxide (NO), and ammonia (NH_3) in the exhaust gases of industrial enterprises. The method is based on capacity of these substances to absorb selectively radiant energy at specific points of the spectral range. The absorption methods can be divided into non-dispersing and dispersing. The non-dispersing methods are based on the selection of a spectral area without spectral dispersion of the radiation. The dispersing methods are based on the selection of a spectral area by spectral dispersion of the radiation. In this case, the photo-absorption method of analysis within the infrared area of the spectre is used. Interference filters are used as dispersive elements. This gas analyser has the following range of measurement:

substance:	**CO**	**NO**	**NO2**	**SO2**	**NH3**
concentration, g/m^3	0-15.0	0-2.0	0-0.5	0- 10.0	0-5.0

Instrument and Laboratory Means of Measurement. Since the number of pollutants in discharged gases reaches several hundred, and the capacities of automated gas analysers are limited, instrument and laboratory methods of analysis play a leading role in Kazakhstan. These measurements are performed by taking samples using electric aspirators of different types and then making an analysis of the samples in a stationary chemical laboratory. In the course of analysis of the samples in the chemical laboratory, general-purpose devices are used, i.e. devices commonly used in applied laboratory work, such as photoelectric colorimeters, spectrometers, polarographs, chromatographs; and others.

Among the instrument and laboratory methods of determining pollution concentrations, the most often used is the chromatographic method. It is based on division of the blend of substances between two phases, one of which is immobile, the other mobile. There are several methods of such division: the main ones are gas chromatography and liquid chromatography. With the help of this method it is possible to determine the content of different hydrocarbons in gases: gasoline, benzene, ketones (acetone, methyl- and ethyl-ketone), isoprene, isobutylene, fatty acids, etc. The photometric technique is used to determine nitric oxides, ammonia, hydrogen sulphide, manganese, lead, hydrogen fluoride, chrome and others. The atomic adsorption method is used to determine magnesium, manganese, copper, selenium, nickel, lead and other metals. As is clear from the above description, a certain number of polluting substances can be determined by different methods. The choice of method depends on the dust content in the sample, the temperature of the sample, and also on the desired precision of measurement, as different methods have different margins of error.

2.1.4. Organisation of the System of Measurements in Kazakhstan

When determining the characteristics needed for the technical means of analysis, it is necessary first of all to identify the basic requirements for the analytical methods. The requirements can be divided into the following: requirements for the means of measurement; requirements for subsidiary equipment of the laboratories; requirements for the means of metrological support; and requirements for the measurement methods.

In conformity with the Law of the Republic of Kazakhstan on Securing Uniformity of Measurements, the following basic requirements have been set for the results of measurements in spheres under state metrological control and supervision:

- the results of measurements must be expressed in established units of physical quantities;
- the margin of error for each result must be specified;
- the margin of error is not to exceed established norms for errors.

Means of measurement applied in the sphere of environmental protection in the Republic of Kazakhstan are tested following the methods of the State Standards Committee of the

Republic of Kazakhstan, with the aim of approving the type of measurement. After having received positive test results, the means of measurement are included, following established procedures, in the roster of the State System for Securing Uniformity of Measurements in the Republic of Kazakhstan (ST RK 2.7-2001 GSI RK. The Procedures for Keeping the Roster of State System for Securing Uniformity of Measurements in the Republic of Kazakhstan). A certificate for a confirmed means of measurement is issued for a limited period (not exceeding 5 years), and after this period the certificate expires and its extension is required. Information about the means of measurement included in the State Roster is published in the reference booklets of the State Standards Committee.

For both the analytical instruments sector and for environmental pollution monitoring, the means of measurement can be divided into two groups – *mobile and stationary*.

Mobile means of measurement are used for carrying out monitoring with the help of mobile stations for atmospheric pollution monitoring and at the specially equipped observation stations. They include gas-analysers and gas-analytical complexes. The mobile analysers of the atmosphere are mainly oriented towards measurement of sulphur dioxide (approximately 30 %), nitric and carbon monoxides (approximately 23 %), ozone (almost 18 %), as well as hydrogen sulphide, carbon disulphide, ammonia, the aggregate of hydrocarbons, methane and dust. This group also includes devices for the measurement of meteorological parameters (temperature of the air, speed and direction of wind, humidity, atmospheric pressure).

Stationary means of measurement are used in analytical laboratories. They include general-purpose laboratory instruments (chromatographs, spectrometers, etc.). For investigations using this type of equipment, the work is divided into procedures for taking samples and those for the analysis of samples. About 80 % of the main eco-analytical problems related to determination of concentrations of polluting substances in the laboratory are approached with this type of means of measurement.

At present in the Republic of Kazakhstan, there are no producers of analytical equipment for the measurement of concentrations of polluting substances. For this reason, in order to carry out an analytical investigation of the quality of the flue-gas samples, it is first of all necessary to select a supplier of analytical equipment, register the given unit of measurement in the roster, and carry out annual check-ups of the procured equipment.

The supply of measuring devices for concentrations of polluting substances is represented by a few distributors in the Republic of Kazakhstan. The most well-known supplier of *mobile* means of measurement is a Russian instrument-building enterprise, OPTEK, which has its representative in the city of Astana. This enterprise specialises in the production of instruments with chemi-luminescent, optical and electrochemical sensors. The means of measurement made by OPTEK are included in the Roster of the State System for Securing Uniformity of Measurements in the Republic of Kazakhstan and have certificates.

Among the suppliers of *stationary* means of measurement, the most significant is an authorised distributor of the American company Agilent Technologies/ Hewlett-Packard: the company Computer Service, Ltd. The offices of the company are located in Almaty. Computer Service, Ltd., arranges the shipment of analytical equipment for composite chromatographic systems to Kazakhstan and also provides service support for the equipment as well as supplies of required accessories and disposable materials.

Verification of means of measurement in the Republic of Kazakhstan is carried out by specialised organisations of the State Standards Committee of the Republic of Kazakhstan (its branches - KazInMetr, NatsEcC and the government agencies authorised for such verification) in conformity with the standard ST RK 2.4-2000 GSI RK.

Verification of Measurement Means. Organisation and Procedures for Implementation. According to the requirements, verification of analytical equipment is to be carried out annually in accordance with approved methods for the verification of each unit of measurement. The same requirements are set for means of metrological support used for the verification of means of measurement. The control blends (CB) and standard samples (SS) that are used for control are to be submitted to a relevant section of the State Roster of Means of Measurement.

In the standardisation system of the Republic of Kazakhstan, the use of only authorised measurement methods (MM) is stipulated. This restriction is specified in the Law of the Republic of Kazakhstan on Securing Uniformity of Measurements. The authorised methods are registered according to the established order in the Roster of Methods of Quantitative Chemical Analysis.

2.2. Methodology for Carrying out an Inventory of Pollution Emissions in Conformity with EMEP criteria (CORINAIR/EMEP Inventory Guidelines)

As was mentioned in previous sections, the state registry of pollution emissions in Kazakhstan – whose aim is the control of sources of atmospheric pollution and state regulation of environmental conditions – is carried out by consolidating emissions data from separate sources (the "bottom-up" approach). The primary registry of emissions is made using results of the inventory of enterprises having sources of polluting emissions. Then the inventory data are consolidated at the oblast, sectoral and national levels. With this system of data collection, it is impossible to register all sources of emission. Moreover, it is not possible to assess the completeness of the information required for submission of national data on emissions to the international level. It is possible to use another approach to assess emissions directly at the oblast, national, or sectoral level (the "top-down" approach): this corresponds better to the requirements of international reporting of aggregate national data, but it does not always take into account the technological specifics of separate industries.

The inventory methods used in different countries can vary significantly, which is why data on emissions can turn out to be incompatible at the international level. In addition, high quality assessments of emissions at national level are required for modeling transboundary streams of pollutants and forecasting the processes of atmospheric pollution. For this reason, the pollution emission inventories under the Convention on Long-Range Transboundary Air Pollution should be made on a uniform methodological base. The use of a uniform methodology is related to the need to provide complete, compatible, accurate, and representative data on emissions in different countries. Such a methodology has been developed by the Co-operative Program for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP) and the European Environment Agency (through its CORINAIR Programme). It is presented in the form of a reference book entitled "Guidelines on the Inventory of Emissions into the Atmosphere". Here, the basic principles of this methodology will be summarised, and the possibilities for its utilisation in Kazakhstan will be considered.

The reference book – "Guidelines on Inventory of Emissions into the Atmosphere" of CORINAIR/EMEP (CORINAIR stands for CORE INventory of AIR emissions), hereinafter referred to as the Guidebook – was developed with the aim of unifying methodologies for carrying out national emissions inventories for reporting at the international level. It was issued for the first time in 1996. In the course of improving and supplementing the calculation methods, a second edition (1999) and a third edition (2001) of the Guidelines were prepared.

The first edition of the Guidebook was translated into Russian by the Meteorological Synthesising Centre East (MSC-East). The Guidebook consists of two parts. In the first part, general issues for an emissions inventory are described. The second part provides methods of emissions assessment. The Guidebook is not a rigid normative document. It allows users to consider the specifics of a particular industry and adjust the use of emission coefficients accordingly. The methods for calculating emissions from specific types of economic activities specified in the Guidebook are periodically reviewed for their improvement and updating, including additions and clarifications.

The Guidelines provide for the application of two basic methods of inventory: *detailed*, based on direct measurements of emissions, and *simplified*, based on the use of industrial statistics (production volumes and fuel and raw materials consumption in particular) and the relevant emission indicators (the "top-down" approach). All emissions sources are grouped by SNAP classification (Selected Nomenclature for sources of Air Pollution) into 11 groups or categories of sources at the first level, shown in *Table I-2*. The categories of pollution sources correspond to the sections of the second part of the Guidebook. In the last edition, a number of sections (groups from 6 to 11) were revised.

Table I-2: *Categories of Emission Sources in the SNAP classification*

	SNAP-code	Categories of sources
1.	010000	Combustion in energy and transformation industries
2.	020000	Non-industrial combustion plants
3.	030000	Combustion in manufacturing industry
4.	040000	Production processes
5.	050000	Extraction & distribution of fossil fuels and geothermal energy
6.	060000	Solvent and other product use
7.	070000	Road transport
8.	080000	Other mobile sources and machinery
9.	090000	Waste treatment and disposal
10.	100000	Agriculture
11.	110000	Other sources and sinks

The SNAP classification has the following structural characteristics:

(a) it has 3 levels: the first one is comprised of 11 categories of sources; the second, 90 sub-categories of sources within the categories; the third, more than 300 types of activities within the sub-categories;

(b) encoding of sources is carried out using 6-digit codes;

(c) both anthropogenic as well as natural sources are covered.

The basic steps in the process of national emission inventory under the Guidelines are the following:

1. Identification of emission sources;
2. Development of a statistical and technological database;
3. Assessment of emission factors;

4. Assessment of emissions by SNAP categories of sources;
5. Assessment of the territorial distribution of emissions.

The methods of emission assessment (simplified and detailed) are described in the second part of the Guidebook. Each chapter of the second part is devoted to a specific category of emissions sources, has a homogeneous structure and starts with the indication of SNAP category and code of the sources, the name of each subcategory or emission stock, and the type of economic activity. In order to use the Guidebook, it is necessary, first of all, to make a comparison of the classification of sources specified therein with the sectoral classification used in Kazakhstan. It should be noted that it is somewhat difficult classify emissions by SNAP category on the base of statistical information available in Kazakhstan. The general classifier of all types of economic activity adopted in Kazakhstan (OKED) – approved as State Classifier by the Resolution № 11 of the State Standards Committee of the Republic of Kazakhstan as of 05/07/1999 as well as earlier effective Classifier of Branches of the National Economy (OKONH) – contains types of economic activity that do not always correspond to SNAP categories. For example, emissions from the SNAP categories 1 and 7 practically correspond in full to the emissions of the economic activities "energy" and "road transport" under the OKED classification; however the classification of road transport adopted in Kazakhstan is different from the classification of the Guidelines. It is also necessary to take into account the fact that in Kazakhstan, as well as in many other EECCA countries, the composition of statistical indicators underwent substantial changes over the past decade. In all other cases, the emissions from economic activity types under OKED can be related to SNAP categories, though with certain assumptions. Thus, in order to use the Guidelines, it is necessary to bring SNAP and OKED categories into conformity. Similar work was done in Kazakhstan during the national inventory of emissions of greenhouse gases, using the methodology of the Intergovernmental Panel on Climate Change (IPCC). *Table I-3* shows an example of aggregation of types of economic activity adopted in Kazakhstan for the IPCC category "Power engineering - fuel re-processing, production and transportation of energy".

Table I-3: *Correlation between IPCC Categories of Sources and OKED classification*

IPCC Category		Types of Economic Activities in Kazakhstan
IA1 Energy and Transformation Industries		
IA1a Electricity and Heat Production		Production and distribution of electric power; Supply of steam and hot water
IA1b Petroleum Refining		Oil refining
IA1c Solid Fuel	*i* Solid Fuel Transformation	Extraction of coal and lignite, peat mining;
	ii Other Energy Industries	Extraction of crude oil and natural gas; services related to oil and gas production; Production and distribution of gaseous fuel; Other sectors of mining industry; Extraction of ferrous ores.
IA2 Industry		
IA2a Iron and Steel	Iron and Steel	Iron and Steel
IA2b Non-Ferrous Metals	Non-Ferrous Metals	Production of non-ferrous metals; Extraction of non-ferrous ores
IA2c Chemicals	Chemical Industry	Production of fertilisers and nitric compounds; Production of pharmaceutical products; Production of rubber and plastic articles; Production of other non-metallic mineral products
IA2d Pulp, Paper and Print		Production of timber and wooden articles; Production of paper and cardboard; Publishing business, printing business;
IA2e Food Processing, Beverages and Tobacco		Production of food articles; Production of tobacco articles;
IA2g Machine Industry	Machine Industry	Smelting; Production of final metal articles; Production of machinery and equipment; Production of agricultural machinery; Production of electric and electronic equipment; Production of transportation equipment;
IA2h Light Industry	Light Industry	Textile and sewing industry; Production of leather, leather articles and production of footwear; Production of furniture;
IA2f Other		
		Other sectors of processing industry
IA3 Transport		
IA3a Civil Aviation		Civil Aviation
IA3b Road Transportation		Urban, road transport
IA3c Railways		Railways
IA3d Navigation		Navigation

Table I-3 shows that in some cases, it is necessary to combine several categories of economic activity types adopted in Kazakh statistics into one IPCC category.

In the case of no measurement data available for emissions assessment, the Guidelines recommend a simplified approach that can be described as follows. The ratio of emissions for a particular sources that can be determined by measurement or taken as an average for the type of the enterprise in the EECCA it is usually called a specific indicator of emissions which is formulated as the amount of emissions per unit of production, or per unit of fuel or raw materials used for production) is multiplied by the volume of production (activity) or by amount of the fuel consumed. If the magnitude of emissions of one or another pollutant per hour is known from measurements, then it is possible to determine the magnitude of emissions per year by multiplying the former by the number of working hours per year. In practice, more complicated calculations are done, as in some cases it is necessary to account for technologies of production and purification of exhaust gases different from those used in Europe.

For making national inventory reports or emissions registers, the annual assessments of emissions are aggregated into databases. The databases are supplemented by other pieces of information: for example, by data on the location of sources, the results of measurements of emissions where applicable, emission coefficients, capacity of enterprises, production volumes or intensity of work in different source facilities, methods of measurement or assessment, etc. As in the sphere of national statistics, the sources of pollution and the lists of pollutants are identified on the basis of the results of an emission inventory carried out by the enterprise (once every five years). Since it is impossible to measure emissions from particular types of sources or for a short period of time from all types of sources, the estimate of their number is carried out on the basis of measurements at selected or representative samples of the (main) sources or types of sources.

In Kazakhstan, national inventory reports on greenhouse gas emissions are made on the basis of the methodology of the Intergovernmental Panel on Climate Change (IPCC). This experience can be used for carrying out a national inventory of polluting emissions, as the methods for both types of inventories are based on the same approach (volume of activity is multiplied by the relevant emission coefficient). However, differently from greenhouse gases, emissions information for EMEP requires an inventory of a greater number of sources and substances to take into account the processes that produce most emissions.

The Guidebook proposes the use of a standard methodology with standard emission factors for many sources. However, the standard emission factors may not always be appropriate in a national context, as they do not take into account technological characteristics of one or another industry: these may be substantially different from western Europe. Often, obsolete technologies and ineffective methods for emissions abatement are still used in Kazakhstan. As a result, Kazakhstan's emission factors might turn out to be significantly higher than those recommended in the Guidelines. For some sources, the standard coefficients of emissions are presented with a relatively wide range of values, with the differences between minimum and maximum values reaching 2 or 3 orders of magnitude. For this reason, the Guidebook recommends the use of national emission factors, if possible, as they are more accurate, provided they have been developed in conformity with relevant CORINAIR/EMEP principles and practices.

The emissions of heavy metals and of persistent organic pollutants (POPs) are practically not registered in state statistics in Kazakhstan because of lack of reliable methods for their calculation. For this reason, it is necessary to compare Kazakh and European specific indicators for industries that represent major sources of heavy metals and POP emissions in Kazakhstan. These sources are enterprises producing coke, copper, zinc, cadmium, lead, etc. At these enterprises, a compulsory registration of heavy metal emissions should be performed. In order to present these data at international level, it will be necessary to collect information on these emissions. Combustion of fossil fuels and production of cast iron and steel are also the sources of emissions of heavy metals in Kazakhstan; however methods of calculation specified in the Guidebook are not applicable to Kazakh conditions. In most countries of western Europe and North America, such methods are well developed and substantial experience has been accumulated in using emission coefficients for the assessment of polluting emissions, including heavy metals and persistent organic pollutants. Obviously, the dissemination of this experience and study of the Guidebook in Kazakhstan could substantially contribute to the introduction of practices for the assessment of hazardous emissions, and it would allow their extensive use for the development of assessment methods for emissions that have not been tracked the state statistical reporting.

It should be mentioned that the CORINAIR/EMEP Guidebook in its present shape (without diminishing its value) is designed for resolution of a limited number of problems: namely, it is first of all oriented towards the compilation of annual national inventory reports to be presented to UNECE. Correspondingly, its use cannot resolve all emissions inventory problems, especially at the local level (the level of the enterprise and individual sources). In particular, it does not specify methods for instrumental measurement of pollutants. Because of its wide regional coverage (the whole of Europe), the proposed emission factors can not account for the specifics of all countries and correspondingly they are rather approximate. That is why application must be accompanied by critical analysis and reference to specific situations and other developments in the given sphere.

2.3. Reporting Framework under the Convention, Nomenclature for Reporting, Guidelines for Emission Assessment and Reporting

The Republic of Kazakhstan, as a Party to the Convention and in conformity with paragraph a) of Article 8 of the Convention, should exchange on “data on emissions at periods of time to be agreed upon, of agreed air pollutants, starting with sulphur dioxide, coming from grid-units of agreed size; or on the fluxes of agreed air pollutants, starting with sulphur dioxide, across national borders, at distances and at periods of time to be agreed upon”. As mentioned in Paragraph 3, Article 10 of the Convention, the Executive Body of the Convention “uses the EMEP Administering Body as an inseparable part of the mechanism of implementing of the Convention in particular with regards to collection of the data and scientific co-operation”.

The Reporting Framework under the Convention is specified in the document EB.AIR/GE.1/2002/7, Draft Guidelines for Estimating and Reporting Emissions Data (hereinafter referred to as the Reporting Guidelines). This document was prepared by the Task Force on Emission Inventories and Projections and the UNECE Secretariat at the request of the Executive Body for the Convention. The purpose of this document is to render assistance to countries in the implementation of a uniform approach for the execution of their obligations under the Convention and its Protocols, to simplify the process of consideration of reports of the Parties on inventories, their analysis and technical assessment. In addition, for preparation of reports, the Parties are to be also guided by the annual plans of work for the implementation of the Convention on Long-Range Transboundary Air Pollution: at present, the document EB.AIR/2002/4, Draft Working Plan for Implementation of the Convention on Long-Range Transboundary Air Pollution in 2003.

In the Reporting Guidelines, requirements for national emissions inventories are specified: they are to be transparent, compatible, comparable, complete and accurate. The Reporting Guidelines prescribe to the Parties the use of the Guidelines for emissions assessment and forecasting by emissions sources. In addition to the methods recommended in the Guidebook, other methods can be used to obtain more precise emissions assessments, provided they are compatible with the provisions of the Guidebook and endorsed by the relevant documents.

The Reporting Guidelines stipulate the minimum amount of reporting under the emission inventories for the categories of sources indicated in the Nomenclature for Reporting, the required format and years of reporting. Paragraph 19 of this document says that each Party to the Convention "must present the data on national annual emissions of air pollutants specified in Paragraph 8 above, them being the object of the agreement to which it is the Party and for the years specified in Paragraph 9 above, with no adjustments related, for example, to climate change or electric power production".

Paragraph 8 lists the following substances:

1. Basic pollutants (sulfur, nitrogen oxides, ammonia, non-methane volatile organic compounds, carbon monoxide)
2. Particulate matter (PM);
3. Heavy metals (cadmium, lead, mercury, and as additional information: arsenic, chromium, copper, nickel, selenium, zinc);
4. Persistent organic pollutants (POPs) (aldrin, chlordane, chlordecone, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex, toxaphene, hexachlorocyclohexane (HCH), hexabromobiphenyl, polychlorinated biphenyls (PCBs), dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and as additional information: short-chained chlorinated paraffins, pentachlorophenol and as additional information: short-chained chlorinated paraffins, pentachlorophenol).

Paragraph 9 specifies the reporting years for emission inventories, which are to cover a complete progression of years starting in 1980, if data are available. For each fifth year starting 1990 (1990, 1995, 2000, 2005 etc.), it is recommended that the Parties submit data on total and sectoral emissions of sulphur compounds, nitrogen oxides, ammonia, non-methane volatile organic compounds (NMVOCs), carbon monoxide, particulate matters, lead, cadmium, mercury, polycyclic aromatic hydrocarbons (PAH), hexachlorobenzene (HCB) and dioxins/furans, for each 50 km × 50 km square of the EMEP net located within its territory.

For each fifth year starting in 1990, it is recommended the Parties to submit the following data about large entity sources (LES): the source type, geographic location co-ordinates (latitude, longitude), amount of emissions of pollutants listed above and, if required, chimney height.

For each fifth year starting in 2010 (2015, 2020 etc.), Parties are to submit data on activities forecast and total national emissions forecast.

In national inventories, emissions data are to be shown by substance under the formats and in the units prescribed in the relevant attachments to the Reporting Guidelines. The data on emissions for the categories of sources indicated in the Standard Nomenclature for Reporting, starting in 2000, should be presented annually under a standard format. In order to facilitate utilisation of the reporting format, blank electronic files of these formats with instructions for filling them in will be submitted to each Party on an annual basis. The information is preferably to be submitted also to the UNECE Secretariat in electronic formats ASCII and EXCEL. The standard reporting format includes data on emission assessments in conformity with the Nomenclature for Reporting (NFR), data on current activities, on planned activities, emission forecasts and other relevant information.

The reporting format is a part of the national emissions report. The data on inventories are to be submitted in the form of tables comprising two parts: minimum required information and additional information. These materials are to arrive to the Secretariat before February 15 each year, and they are to be for the reporting period of the full year before the preceding one, i.e. by February 15, 2003, data for the calendar year 2001 (from January to December 2001) must be submitted. The data by squares of the EMEP grid must be presented not later than March 1. The information report must arrive at the Secretariat not later than three months after submission of the emissions data. It should include a description of the methodologies and assumptions used as well as references and sources of information, data on calculations, and information on symbols, ambiguous issues and procedures for data supply and quality control. Selected parts of the report should describe changes in methodologies, assumptions and sources of information in comparison with preceding years, if there are any, and assumptions and basic characteristics used for making forecasts, including GDP (in constant 1990 prices) and population assumptions. It is recommended that data on inventories and information on emissions be placed on the Internet.

Each Party should collect and keep all the available information on emissions for each year, including data on emission coefficients, in an adequate database. It is recommended that the Parties collect and consolidate all emission information available at a single national body, if possible. The document states that, if necessary, the Reporting Guidelines can be reviewed by the Task Force on Emission Inventories and Projections not later than 2007, with the aim of assuring effective reporting and compliance with changing requirements. It is to be noted that these changes are to be minimal and of technical/procedural character.

When presenting reporting materials under the Convention, it is necessary to follow the specifications of the Guiding Principles in terms of reporting format, reporting nomenclature, use of industrial statistics data, description of methodologies and assumptions used and of references and sources of information, information on recalculation, data on symbols, ambiguous matters, procedures for supply and quality control, planned activities and emissions forecasts.

2.4. Data Omissions and Needs Assessment

Having become a Party to the Convention on Long-Range Transboundary Air Pollution, Kazakhstan in 2002 presented to the UNECE Secretariat its available data on pollution emissions in the form of data tables for the period from 1990 to 2000. The submitted information included total national emissions and emissions for six administrative oblasts, the cities of Almaty and Astana and some large entity sources. This was the first attempt to submit information based on available reporting by enterprises and on industrial statistics. Table I-4 shows the consolidated data submitted by Kazakhstan to the UNECE.

The report was submitted by the Ministry of Environmental Protection, i.e. the state body responsible for EMEP. The submitted data on large entity sources were received from enterprises using form No. 2-TP (air) for basic pollutants (SO_2, NO_2, CO) and for solid particles. Total national data and the data by administrative oblast were prepared by consolidating data obtained from the enterprises.

Table I-4: *Emissions of Pollutants into the Atmosphere in Kazakhstan, in thousand tonnes*

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total:	**5180.86**	**5668.61**	**5531.96**	**5508.57**	**4546.46**	**4423.16**	**3866.0**	**3903.19**	**3819.51**	**3614.12**	**3543.06**
Particulate matters	1268.12	1218.99	1163.74	1070.34	886.40	912.38	782.88	666.20	617.60	586.01	585.97
Sulphurous anhydride	1156.33	1295.54	1295.76	1285.18	1093.48	1083.36	804.54	937.88	961.19	880.98	947.99
Nitrogen oxides	355.69	400.52	377.89	372.25	296.56	282.71	251.95	213.23	228.01	205.18	200.89
Carbon monoxide	1639.90	1975.30	1959.49	1801.36	1425.86	1421.92	1450.55	1378.79	1345.42	1187.39	1114.27
Hydrocarbons	582.39	577.89	563.72	546.39	481.46	372.80	330.55	335.23	309.08	347.378	304.28
Ammonia	0.49	0.42	0.69	0.61	0.39	0.32	0.07	0.07	0.26	0.27	0.27
Lead	0.5	1.1	1.1	1.1	1.6	2.9					
Copper	1.8	1.5	1.1	1.4	0.62	2.67					
Arsenic	1.6	1.7	1.8	2.1	1.7	3.1					
Hydrogen sulphide	0	0	0	0	1.35	0.01	0.03	0.05	0.04	0.03	0.02
VOCs	0.394	0.465	0.558	0.565	0.7	1.222	0.132	0.083	0.026	0.041	0.22
POPs											

It should be mentioned that the state statistical reporting only includes emissions from stationary sources. Emissions from road transport and other mobile sources (railways, aviation, river and maritime transport) are inadequately recorded. Format 2-TP (air) does not comprehensively request data on mobile sources, including road transport. There is only one state statistical reporting form for road transport enterprises, and it does not request any environmental information: this form covers data on the number of transportation units, total mileage, and total amount of fuel consumption. The form is used for annual and semi-annual reporting. Information from this form can be used for the calculation of emissions from road transport sources.

Emissions from mobile sources are calculated in the draft norms on maximum allowable emissions (MAE) and ecological passports. For the annual calculation of payments for environmental pollution (polluting emissions into atmosphere, discharge of pollutants into water sources, disposal of waste), emissions from transport are not calculated and the fee is charged on the grounds of the amount of fuel used. The payment rate is stated per tonne of diesel fuel and petrol (ethylated and non-ethylated) used.

In calculating emissions from mobile sources, the manual "Methods for the Determination of Payments for Air Pollution from Mobile Sources", published by the Ministry of Ecology and Bio-resources in 1996, is used. *Table I-5* below shows specific indicators of emissions (in tonnes per tonne of consumed fuel). Emissions of the following pollutants are calculated: carbon oxides, hydrocarbons, aldehydes, soot, benz(a)pyrene, nitrogen oxides, sulphur dioxide. For calculation, only the amount of consumed fuel is required. A sample calculation is shown below in *Table I-5*.

Table I-5: *Example of the Calculation of Polluting Emissions from Road Transport*

Pollutant	Number of vehicles and mechanisms	Type of fuel consumed, t	Specific emissions of pollutants, t/t	Gross emissions of pollutants, t/yr
Carbon oxides	13	diesel	0.047	2.453
Hydrocarbons		52.2	0.019	0.992
Aldehydes			0.0034	0.177
Soot			0.0092	0.480
Benz(a)pyrene			0.14×10^{-6}	7.308×10^{-6}
Nitrogen oxides			0.033	1.723
Sulphur dioxide			0.01	0.522
Carbon oxides	8	petrol	0.42	14.532
Hydrocarbons		34.6	0.046	1.592
Aldehydes			0.0012	0.042
Soot			0.0011	0.038
Benz(a)pyrene			0.1×10^{-6}	3.46×10^{-6}
Nitric oxides			0.027	0.934
Sulphur dioxide			0.002	0.069

Sometimes, the total number of vehicles (or other transportation units) is shown, but this value is not used in calculations. As one can see from the table, the calculation of emissions of heavy metals is not provided for in these methods. For the purpose of making annual national inventory reports to UNECE, lead emissions can be calculated proceeding from the amount of ethylated petrol consumed. The data on consumption of ethylated petrol are not present in published statistical booklets. However, they can be obtained from the Statistics Agency by a special query from the Ministry of Environment Protection (MEP) of the Republic of Kazakhstan.

In addition to the need to improve compilation of emissions from mobile sources, it is necessary to mention the lack of registration of emissions from area sources and natural sources, accidents and fires.

Analysis of omissions and deficiencies in the data required for annual reports on emissions to be submitted to the UNECE reveals the following main difficulties and problems related to the emissions inventory for Kazakhstan:

- There is a discrepancy between the characteristics of the national inventory of emissions and the international requirements of EMEP.
- The list of substances subject to industrial emissions control and reporting is limited, i.e., it does not include some substances to be presented to the UNECE (for example, data on emissions of persistent organic pollutants, POPs, and heavy metals, HM).
- There are no methods to estimate emissions of these pollutants (POPs and HM).
- Existing procedures for the national emission inventory are based on the "bottom-up" approach, and the inventory is carried out under a sectoral principle but not a technological one.
- There are problems related to the lack of completeness of information (there is no consistent state registration of emissions from mobile and natural sources).

2.5. Quality Control, Data Assessment and Analysis of Ambiguities

The national report to be submitted to the UNECE Secretariat requires inclusion not only of data on pollution emissions but also a description of the methodology used and information to make an assessment of the quality of the submitted data. To verify the validity of calculations, it is necessary to use industrial statistics. In this case only, it is possible to determine an approximate emission coefficient. If this coefficient falls into the certain range of the emission coefficients included in the reference Guidebook, then it is considered that calculations were performed correctly. However, in some countries, the coefficients of emissions are too large compared to the values in the Guidebook, as the industrial technologies used are obsolete and sometimes there are no systems for the abatement for discharged gases at all.

The methods for the verification of emission inventory data are described in a separate chapter in the first Part of the Guidebook. This chapter does not cover all possible methods of control; rather, the conceptual approaches for planning and the principles for assuring data quality guarantees and control are described in detail. First of all, this chapter provides key criteria to contribute to a general understanding of the procedures for the verification of the materials of the emission inventory. These are such criteria as accuracy, reproducibility, authenticity, reliability, quality control, ambiguity, ratification, verification, clarity and consistency. The concept of verification can be applied at different levels, analytical and policy related: the analytical level requires more precise and narrow error limits; the policy related-level, conformity of the submitted data to the norms of international agreements and consistency of the methods applied. The selection of verification methods depends on the sphere of application of the inventory data or on the type of request from data users.

Since the majority of emission data is the results of assessments or calculations, it is often difficult to define precisely the quantitative error limits, i.e. to assess the uncertainty of the data. Nevertheless, it is possible to determine a probable minimum and maximum for the emissions data, i.e., a quantitative parameter characterising data quality. In a number of cases, the following might be used: indicators or monitoring analysis of data quality, direct testing methods or a rating method. In all the cases, the method of preference is a formal analysis of errors, to be carried out to control the submitted data.

Usually for emission assessments, a less strict approach can be used, and it can be characterised by calculation of the annual total emissions of a whole industrial sector and the determination of general annual trends. As a rule, it is more convenient to determine emissions for large industrial sectors and not for separate sources. The basic purpose of assessment is the estimation of the main causes of air quality problems. During the calculation, it is possible to use aggregated data, for example, on the composition of motor vehicle fleets and the total volumes of fuel sales, to list various assumptions. If the data on emissions are used for modeling air quality, then the requirements for inventory data must be stricter.

Verification must be performed by an inventory official and must be thoroughly planned. It is stressed in the Guidebook that the complexity of inventory methods and instability of operation of polluting sources does not allow the development of universal recommendations for all the spheres of application of inventory data. Nevertheless, it is presumed that for assessments of the quality of the inventory data, an applied method can be developed with the help of the Guidebook.

2.6. Emission Scenarios

In the CORINAIR/EMEP Inventory Guidebook, substantial information is given on methods and approaches for projecting pollution emissions. A lot of simplifications based on key assumptions are used for making emission forecasts. For example, in order to make an emission forecast it is necessary to evaluate future emissions factors: here, assumptions are required on the introduction of new technologies. For determination of future levels of activity, statistical data are required. In making emission projections, these data can be obtained from economic scenarios and from assumptions of human behaviour and of the performance of economic sectors. At the national level, different approaches and assumptions based on key factors are used. In addition, projections must be considered as scenarios, not forecasts.

In some countries, models are used for emissions estimates. The models used at national level differ in important aspects. They were developed for different purposes, initially were used to answer different questions and cover different time periods. Some models follow an imitational approach; others are based on methods for economic optimisation. In Kazakhstan, there has been experience using the ENPEP model of energy-related planning for forecasting emissions of greenhouse gases. This model was developed by the Argon National Laboratory (USA) for use by the International Atomic Energy Agency (IAEA) for developing countries; for utilisation in transition economies, it was adapted to the conditions of Kazakhstan. The model combines the dynamics of market processes taking place in the energy sector through a detailed presentation of market balance, i.e. it balances demand and supply. It is used for modeling the power system of a country in general, but it does not allow an economic analysis, and therefore it occupies an intermediary position between engineering, energy and pure balance models. The ENPEP model is used for analysis of entire energy systems and investigation of the electric power-generating sector. The model is organised in a module format to provide flexibility and simplicity in its utilisation, and it is rather detailed, especially for the electric-power-generating sector.

The ENPEP model contains a module allowing the calculation of emissions of pollutants from fuel combustion in the course of power generation and it can be used for projecting future emissions. In other sectors in Kazakhstan, no forecasting of greenhouse emissions has been done. In principle, for the non-energy sector other approaches can be used and the results obtained via different methods can be combined. For practical applications, this will require additional research. For this reason, study of the Guidelines and of experience from other countries can be of great use for the development of appropriate approaches and assessments of future emissions that take into account the directions of economic development, for example using the results of macroeconomic modelling in Kazakhstan.

3. Conclusions

As the result of the analysis made of the emission inventory in Kazakhstan, it can be concluded that, although the reporting system is rather strictly observed (all the enterprises must report about their emissions of pollutants), in general data on emissions appear to be incomplete, in terms of the categories of emission sources used and of the pollutants tracked. Understanding these problems will contribute to improving the emission inventory. According to the experts' opinion, among the reasons for the lack of completeness of the national inventory of emissions are the following:

- Excessive adherence to the "bottom - up" principle, with data collected only at the level of enterprises, without the use of alternative approaches;
- Excessive centralisation – inventory improvement can also start at a local level;
- Strict laws and instructions are not supported by realistic, modern and complete methods of calculation for all types of pollutants present in emissions of enterprises;
- There is no clear (systematic and complete) understanding of which pollutants are emitted by specific enterprises and what they are to report on;
- Processes and sources of pollution have not been sufficiently researched. This results in an absence of a stable link between the emissions inventory and scientific research on emission sources. Because of this, methodologies and methods that are 20 years old are still being used.

According to the analysis made, the following conclusions can be drawn:

- Existing calculation methods only allow the preparation of emission assessments with a significant degree of uncertainty. Each assessment is to be considered as a sort of approximation to the real value. Critical attitudes towards information on emissions will contribute to the improvement of the accuracy and quality of the inventory;
- Obtaining information on emissions is not only a policy problem, but also a scientific one, and accordingly it requires the development of national research in this sphere;

- The data from state statistical reporting are incomplete *a priori* as they only reflect part of the situation, since they were developed using emissions knowledge from the 1970s and 1980s. They provide a starting point for improving emission reporting;
- In carrying out the national emission inventory, it would be useful to employ alternative approaches. The "top-down" approach deserves equal attention to the "bottom-up" approach;
- Reporting of emissions of heavy metals and of persistent organic pollutants (POPs) is particularly incomplete in Kazakhstan;
- Emissions from road transport and other mobile sources are also reported incompletely, and special attention should be paid to improving their inventory, taking into account their contribution into their contribution to pollution levels in urban air basins;
- Emissions from households, from most area and natural sources, accidents, fires are not registered;
- The available information on emissions (not only by composition of the registered sources but also by other characteristics) does not meet the requirements of the information users, in particular for the purpose of regional as well as local modelling;
- In calculating pollution emissions from enterprises, calculation methods are largely 20 years old;
- There are no material or technical capacities for reviewing all the methods for the country's effort;
- Wider use of methodological and scientific developments in the sphere of emissions research, along with international experience (especially with regards to inventories of specific pollutants with a high cost of determination and requirements for their sensitivity to analysis), is the only way to improve the situation concerning methodologies for the emission inventory. International experience is summarised in such publications as the EMEP/CORINAIR Inventory Guidelines, IPCC/MGEIK Work Book, AP-42 and other publications.

Co-ordination of emission information improvement efforts with other EECCA and other UNECE countries in general is quite limited at present (it is related to links with the working groups on emissions in other EECCA countries) and should be reinforced.

4. Recommendations for Kazakhstan for the Improvement of Air Pollution Emissions Inventory Systems, to meet EMEP guidelines

One of the basic tasks of this research is to develop recommendations for Kazakhstan for carrying out inventories of pollution emissions, in particular to improve the country's annual reporting on emissions to UNECE. The following recommendations were developed at a seminar in Kazakhstan, with participation of local and international experts and representatives of interested enterprises, and in the course of subsequent consultations and discussions.

High quality information on emissions of pollutants into the atmosphere is necessary for the resolution of various problems related to implementation of international commitments, including information support for transboundary pollution modelling, monitoring of pollution emissions at subnational, national, and regional levels, assessment of the impact of pollutants on human health, ecosystems, and infrastructure, and strategic planning for industrial sector development. It should also be noted that the demand for emission information has been growing recently, both within the country as well as from the international community. Requirements in terms of the content of information and its quality are also growing steadily, in particular on the part of the EMEP programme. Taking into account the fact that the methodological foundations of currently used procedures for emission inventories were formulated about 20 years ago and do not meet current needs, applying the basic principles of the EMEP methodology for emission inventories is important and timely for the improvement of the status of emission assessments; moreover, the principles for data submission and reporting (transparency, clarity, verification, etc.) need to be observed.

In order to obtain reliable assessments of emissions in Kazakhstan, much work must be done to provide experts with the new methods for carrying out the inventory. First of all, the latest version of the EMEP/CORINAIR Inventory Guidebook, and all its subsequent amendments, should be translated into Russian. Another important task is the preparation (in Russian), publication, and dissemination of manuals and reference materials on emission inventories relevant to Kazakhstan. Moreover, EMEP centres and experts can be of great practical help in terms of training and improving professional skills of Kazakh experts in the sphere of emission inventories, as well as organising workshops and training courses to discuss and resolve inventory problems. Opportunities to establish and maintain contacts and exchange information with other EECCA countries, as well as create common informational networks, web-sites, and special working groups, will contribute to raising the quality of inventory work and help meet EMEP requirements.

Based on the discussions of activities needed for the improvement of the emission inventory system in Kazakhstan, a list of recommendations was prepared for strengthening data collection and reporting in order to meet the Kazakhstan's commitments under the Convention on Long-Range Transboundary Air Pollution:

I. Organisation of activities on the Convention:

1. National institutions should establish a special working group for the preparation of national inventories and national emissions data in Kazakhstan, considering the following issues:

    - Identify the range of tasks for inventory improvement in terms of their the importance and the solutions required, and develop an action plan for the upcoming years;

    - Prepare and submit to UNECE national emissions data on an annual basis;

- Identify criteria to characterize information quality and completeness and include the resulting information in annual emissions reports;

2. Establish permanent contacts between the national emissions working group and similar groups in other countries, and promote participation in international seminars, training courses and exchange of experience;

3. Reporting on emissions of enterprises shall be transparent;

4. Ensure that monitoring data on pollution concentrations in enterprise emissions are accessible for the calculation of emissions factors;

5. Consider step-by-step accession of the Republic of Kazakhstan to the CLRTAP Protocols;

II. Methodological Basis for Improving Emissions Accounting

1. Support the work of the Meteorological Synthesising Centre - East (MSC-East) to translate the EMEP/CORINAIR Emission Inventory Guidebook into Russian;

2. Support the preparation and publication of the EMEP/CORINAIR Emission Inventory Guidebook in Russian, taking into account the specific situation of Kazakhstan;

3. Implement new projects for the expert assessment of pollutant emissions, in particular emissions of persistent organic pollutants (POPs) and heavy metals (HM);

4. Encourage national participation in international training courses and workshops, and support their planning; workshops on methods for the inventory of emissions from mobile sources and of persistent organic pollutants (POPs) are a priority;

5. Develop research into emission processes and sources.

III. Methodological assistance and training needs:

1. Support links with the EMEP coordinating centres (MSC-W, MSC-E, CCC, CIAM) and experts for support in the organisation and implementation of emission inventory activities and training for Kazakhstan specialists;

2. Review the EMEP/CORINAIR Inventory Guidebook in order to apply it as a uniform international methodology for making emission inventories, improving in particular methods for the assessment of pollutants that not currently covered in enterprise reporting;

3. Expand the application of international methodological and scientific experience in the sphere of emission research. This experience is summarized in volumes such as the EMEP/CORINAIR Inventory Guidebook, IPCC Guidelines on national greenhouse gases inventories, AP-42 and others;

4. Ensure the active participation of national experts in the work of the Task Force on Emission Inventories and Projections (TFEIP) and the EMEP management body;

5. Inform UNECE of the importance of translating the most recent version of the EMEP/CORINAIR Inventory Guidebook from English into Russian;

6. Organise annual workshops for training and exchange of experience in the application of the EMEP/CORINAIR Emission Inventory Guidebook in Kazakhstan;

7. Use the experience and capacities of EMEP centres and experts;

IV. Methodology and research activities:

1. As a priority, review the emission inventory situation in Kazakhstan. Inventories should be broken down by category of pollutant, with the objective of assessing the completeness of available information reported by enterprises. It is useful to have experts assess emissions of key pollutants and to compare the results against available monitoring data;
2. Compare national data with the emissions indicators and emissions factors recommended in the EMEP/CORINAIR Inventory Guidebook;
3. Adapt, where necessary, the emission factors recommended by the Guidebook to conditions in Kazakhstan;
4. Make assessments of emissions of emissions of heavy metals (HM) and persistent organic pollutants (POPs), through co-operation between national experts and EMEP centres;
5. As a priority, review current methods for calculating emissions and measuring pollutant concentrations in emissions, check their correspondence with current international knowledge and approaches, and create a schedule for their revision;
6. Improve the classification of economic actors (and sectors), introducing the coding system proposed under the IPCC and SNAP;
7. Develop inventory systems on the basis of internationally recognized approaches (e.g., “top-down”), in particular following EMEP methodology; in parallel, improve the current inventory system approach in Kazakhstan (using the “bottom - up” approach).

PART II. AIR POLLUTION MONITORING AND MODELING

1. Environmental pollution monitoring and modeling in Kazakhstan

1.1. The monitoring system

Ensuring a safe environment as a component of the sustainable national development and preventing harmful anthropogenic impacts on the environment and human heath are fundamental directions for environmental protection activities in the Republic of Kazakhstan.

In the Long-term Strategy to 2030, Environment and Nature Resources, the goal of the first period (2001-2010) is the stabilization of environment quality.

In compliance with current legislation, a Unified State System for Environmental and Natural Resources Monitoring shall be put in operation in the Republic; its activities are to be implemented by specially authorized state bodies.

The Unified State System for Environmental and Natural Resources Monitoring is to provide timely and reliable information on the state of environment, this being a basis for decision-making for environmental protection by governmental bodies and other agencies, as well as for the assessment of the effectiveness of environmental protection measures being taken and the prevention of emergency situations.

1.1.1. Legal and regulatory base

Several Governmental Resolutions and Laws of the Republic of Kazakhstan provide the basis for pollution monitoring:

- Article 24 of the Law of the Republic of Kazakhstan ***on Environmental Protection***, of 15 June 1997;
- Article 112 of the ***Water Code*** of the Republic of Kazakhstan of 31 March 1993;
- Article 21 of the Law of the Republic of Kazakhstan ***on Atmospheric Air Protection***, of 11 March 2002;
- The Resolution of the Government of the Republic Kazakhstan No. 885 of 27 June 2001, ***on Approval of the Rules for Establishing and Carrying out the Unified State System of Environmental and Nature Resources Monitoring.***

The Unified State System for Environmental and Natural Resources Monitoring is considered to be a multi-purpose information macro-system, including observations and monitoring of the environmental and natural resources conditions, as well as the analysis of data on current conditions to ensure environmental safety and conservation and the growth and rational use of natural resources.

The Unified State System for Environmental and Natural Resources Monitoring is aimed at providing information to make management and economic decisions, as well as monitoring the use of nature resources and informing the public of environmental conditions and the impact of environmental factors on human health.

The Environmental Pollution Monitoring System is a component of the Unified State System of Monitoring.

The national Hydrometeorological Service has carried out monitoring of environmental pollution since 1972.

In RK Governmental Resolution ***on Establishing the Republican State-owned Enterprises Kazhydromet and Kazaviamet,*** No. 185 of 2 March 1999, among the main tasks for Kazhydromet, the following are specified

- Carrying out monitoring of the natural environment;
- Maintaining the Republican Database of Environmental Pollution Data;
- Providing governmental bodies, economic branches and the public with information on environmental pollution conditions and trends.

1.1.2. Goals and tasks

Pollution monitoring is carried out for the provision of information on the pollution levels of main environment media, for decision-making in the field of environmental protection, including assessments of the effectiveness of protection measures.

The tasks of environment monitoring are as follows:

- Systematic observations by network stationary sites of pollution levels in main environment media (air, atmospheric precipitation, snow cover, surface water, soil and radiation) for a regulated set of parameters, frequencies and volumes;
- The organization of observations of pollution in transboundary watercourses at sites located on or near national boundaries;
- Collecting, processing and analyzing information on the state of environmental pollution of the Republic of Kazakhstan;
- Developing and updating a unified information system for pollution monitoring.

1.1.3. Structure of pollution monitoring (territorial and republican level)

As in many countries, the basis of the environmental monitoring system is a ***unified observation network***, which is closely linked with the meteorological stations and hydrological posts of the National Hydrometeorological Service.

Observations are required to be ***systematic*** and ***comprehensive*** and to ***comply with*** the terms of typical meteorological and hydrological situations.

To ensure the ***comparability*** and ***validation*** of observation data for environmental pollution (air, atmospheric fall-outs and precipitation, soil, surface water, radiation), all methodological recommendations for the implementation of activities, starting from observations and ending with information processing, shall be unified and mandatory for all subdivisions of Kazhydromet.

The system of pollution monitoring within the structure of the National Hydrometeorological Service is built following hierarchical principle and has two levels:

The territorial level is represented by network laboratories of the Oblast Hydrometeorological Centers (territorial centers). These laboratories:

- organize, coordinate and control monitoring for the network within the jurisdiction of their territories;
- carry out analysis of air and surface water samples (according with available laboratory equipment);
- collect, process, integrate and analyze individual observations of environment conditions and communicate the resulting information, following established orders and terms, via paper or magnetic mediums.

The ***National level*** is represented by the Center for Environmental Pollution Monitoring of Kazhydromet, whose major functions are as follows:

- collect, process, analyze and integrate the information and data on environmental pollution obtained by the environmental monitoring network;
- assess and forecast environmental conditions of the country and of specific areas with high pollution loads;
- develop and up-date national data banks on pollution;
- carry out environmental monitoring in Almaty city and Almaty oblast;
- process and analyze precipitation, soil and horizontal map-case samples that come from the observational network;
- prepare and print monthly and annual environmental bulletins.

The ***network of laboratories*** for environment pollution monitoring includes (see *Table II-1*):

- four analytical groups in the city of Almaty (for atmospheric air, surface water, physical and chemical methods of analysis and radiometry);
- a series of laboratories under the Oblast Hydrometeorological Centers: ten complex laboratories; eight laboratories for the observation for atmospheric air pollution; and one laboratory for the observation of surface water pollution.

Table II-1: *List of laboratories within Kazhydromet system on environment pollution monitoring*

No.	City	Type of stationary laboratory			
		Complex (air + water)	Atmospheric air	Surface water	Radiometric
1	Astana	+			
2	Aktubinsk	+			
3	Almaty		+	+	+
4	Atyrau	+			
5	Leninogorsk		+		
6	Semipalatinsk		+		
7	Ust-Kamenogorsk		+	+	
8	Taraz	+			
9	Uralsk	+			
10	Balkhash	+			
11	Zhezkazgan		+		
12	Karaganda	+			
13	Temirtau		+		
14	Kostanai	+			
15	Aktau		+		
16	Petropavlovsk	+			
17	Pavlodar		+		
18	Ekibastuz		+		
19	Shymkent	+			
	Total - 22	**10**	**9**	**2**	**1**

1.1.4. Environmental pollution monitoring subsystems

Depending on the tasks involved in measuring environmental components, the state environmental pollution monitoring system includes:

- air pollution monitoring, including precipitation;

- surface water pollution monitoring;
- soil pollution monitoring;
- radiation monitoring;
- background monitoring.

1.2. Air pollution monitoring

The air pollution monitoring network obtains information on ambient air pollution in the cities and industrial centers of the Republic of Kazakhstan and has the following tasks:

- observations for atmospheric air pollution;
- notification of concerned agencies of extreme pollution levels.

Observations of atmospheric air pollution levels are carried out at stationary posts by specialists of the National Hydrometeorological Service.

The number of stationary posts and their location in each specific populated area has been defined taking into consideration population, geography, and current pollution levels, as based on normative documents.

The list of controlled pollutants has been defined taking into account the volume and composition of air pollution emissions as well as results of preliminary investigations of ambient air pollution.

1.2.1. The air pollution monitoring network (number of observational sites and their location)

The National Hydrometeorological Service network includes 47 stationary observation pollution posts (OPP), which are located in 20 settlements (*Table II-2 and Figure II-1*).

Table II-2: *List of air pollution observational sites*

No.	Settlement	Number of posts
1	Astana	2
2	Aktubinsk	3
3	Aktau	1
4	Almaty	3
5	Atyrau	2
6	Balkhash	2
7	Glubokoye village	1
8	Taraz	4
9	Zhezkazgan	2
10	Karaganda	4
11	Kostanai	2
12	Ridder	2
13	Pavlodar	2
14	Petropavlovsk	2
15	Semipalatinsk	2
16	Temirtau	2
17	Uralsk	1
18	Ust-Kamenogorsk	5
19	Shymkent	4

No.	Settlement	Number of posts
20	Ekibastuz	1
	Total	**47**

1.2.2. Observation and measurement program

To obtain representative assessments of air pollution conditions in the development of the observation program, the following provisions have been taken into account: the "Guidebook on Atmosphere Pollution Control" (RD 52.04.186-89) and the document on "Nature Protection. ATMOSPHERE. Rules for Air Quality Control in Populated Areas" (GOST 17.2.3.01-86).

Of the 47 OPP posts, 44 make observations on a daily basis (excluding weekends) following short programs (3 times a day, at 7 a.m., 1 and 7 p.m.). The other three posts, located in Almaty, Astana and Karaganda, are located at the sites of the main meteorological stations and work on complete program (with four observations a day, at 1 and 7 a.m., and 1 and 7 p.m.).

1.2.3. List of controlled pollutants

The list of controlled pollutants has been defined taking into account the amount and composition of air emissions and the results of preliminary investigation of air pollution.

Sixteen ingredients are specified for air pollution observations, including dust, sulfur dioxide, dissoluble sulfates, carbon monoxide, nitric dioxide, hydrogen fluoride, hydrogen sulfide, heavy metals (*Table II-3, Figure II-2*).

Figure II-1. *Atmospheric Air Condition Observational Network*

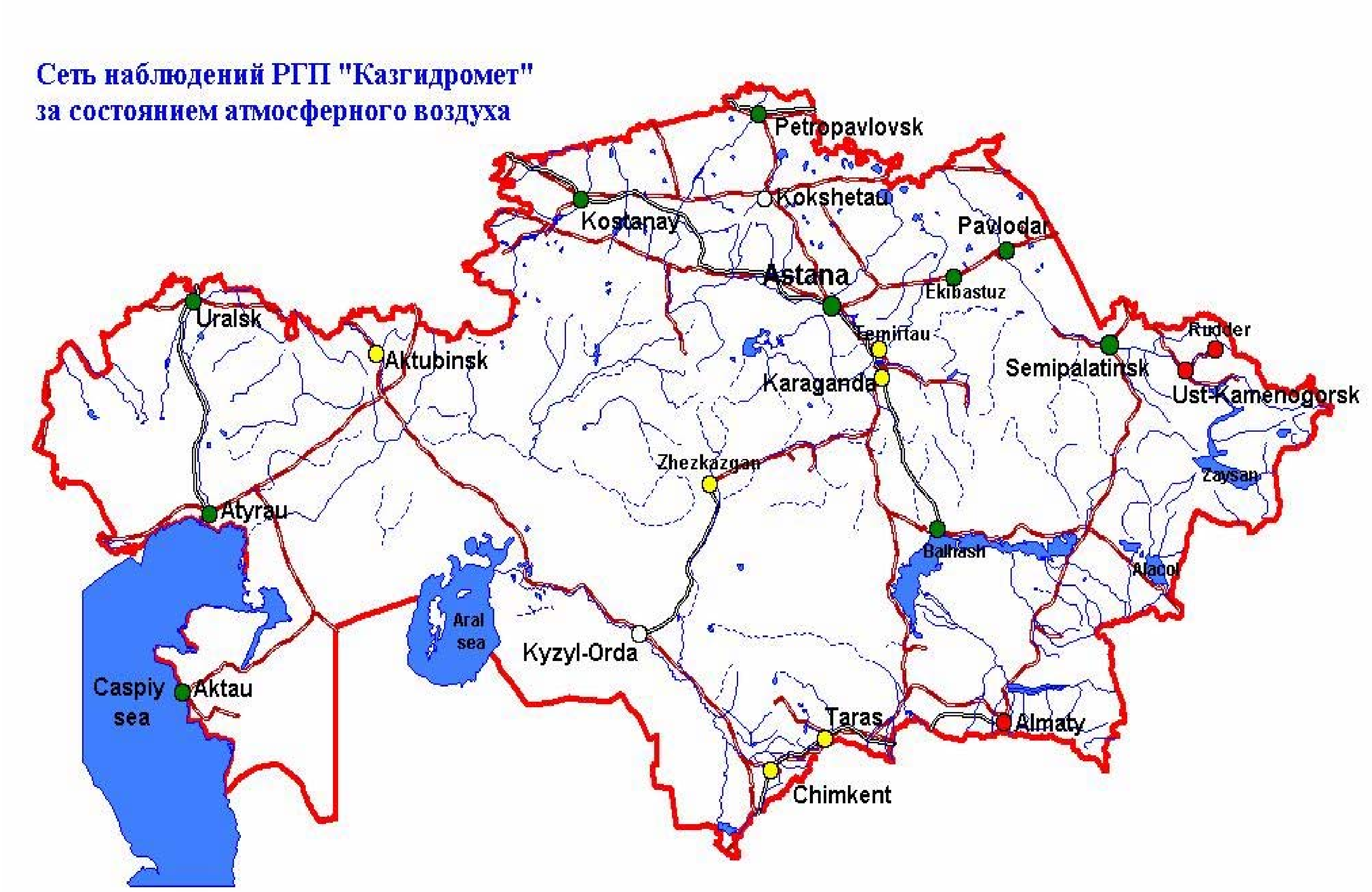
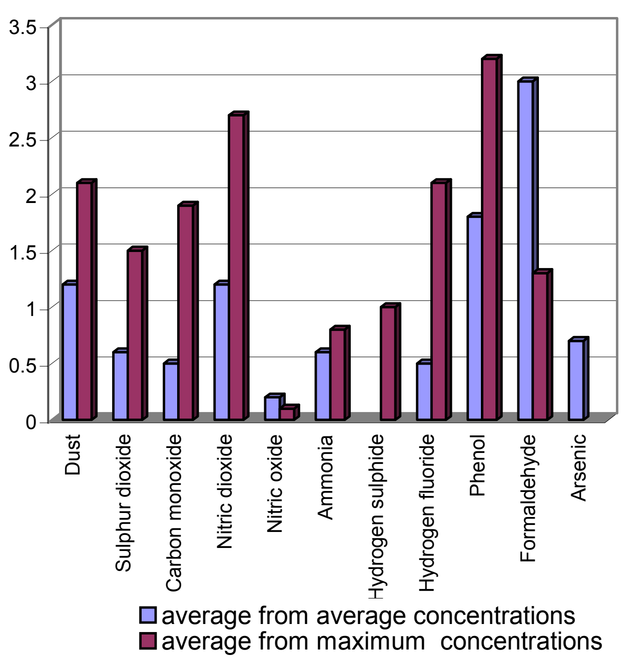


Table II-3: *Average Values of Air Pollutants in Populated Areas (data for 2002)*

Pollutant	Number of cities	Average for cities				Number of cities in which MAC exceeded
		Average concentrations		Maximum concentrations		
		mg/m^3	Multiple of MAC	mg/m^3	Multiple of MAC	
Dust	20	0.17	1.2	1.07	2.1	17
Sulfur dioxide	20	0.0291	0.6	0.7649	1.5	2
Dissoluble sulfates	9	0.007		0.049		
Carbon monoxide	15	1.4	0.5	9.57	1.9	9
Nitric dioxide	20	0.046	1.2	0.233	2.7	19
Nitric oxide	4	0.014	0.2	0.055	0.1	0
Ammonia	5	0.024	0.6	0.168	0.8	1
Hydrogen sulfide	6	0.0015		0.008	1.0	2
Hydrogen fluoride	2	0.0026	0.5	0.0410	2.1	1
Sulfuric acid	1	0.012	0.1	0.09	0.3	0
Phenol	9	0.0053	1.8	0.0317	3.2	7
Formaldehyde	9	0.0091	3.0	0.0470	1.3	5
Chlorine	2	0.018	0.6	0.095	1.0	0
Hydrogen chloride	1	0.050	0.5	0.88	4.4	1
Ozone	1	0.0097	0.3	0.130	0.8	0
Arsenic	3	0.0020	0.7	0.015		
Chromium	1	0.0010	0.7	0.0073		

Figure II-2: *Average pollution concentrations (in terms of maximum admissible concentration levels) in cities of the Republic of Kazakhstan in 2002*



1.2.4. Meteorological characteristics

The transport and diffusion of pollutants emitted into the atmosphere depend on physical laws; the periods that pollutants remain in the air depend on many factors, the dominating one being meteorological conditions. Large particles in the air undergo gravitation deposition; chemical and photochemical reactions take place between various substances; and these are transported over large distances and washed out of the atmosphere by precipitation. Under the influence of all these factors, tropospheric pollution levels – even with continuous air emissions – may fluctuate within rather wide ranges.

As a result, the task of protecting air quality in cities depends to a considerable extent on understanding of the role of meteorological factors and considering properly the ability of atmosphere to dissipate and remove harmful substances emitted into it, i.e. the ability of atmosphere for “self-purification”.

Simultaneously with air sampling, the following meteorological characteristics are observed: wind speed and direction, air temperature and humidity, and atmospheric phenomena. These observations allow a determination of the dissipation of pollutants in the atmosphere.

1.2.5. Precipitation pollution monitoring (observational network, program of sampling)

Data on the chemical composition of ***precipitation*** indicate the extent of atmospheric pollution, especially in the layer where clouds form and gas exchanges occur, and from which precipitation falls.

Data on pollutant contamination in ***snow cover*** are the only source of information for qualitative and quantitative regional assessment of atmospheric pollution in winter on the territory of Kazakhstan, and also identify pollutant dispersion area and the transport and volumes of pollutants precipitating from emissions of industrial enterprises, including transboundary transfer.

The observation network on chemical contamination in precipitation functions on the basis of network of meteorological stations, operating within the Kazhydromet system and located both in rural and urban regions (*Table II-4, Figure II-3*).

Table II-4: *Observational network on the chemical composition of precipitation*

No.	Hydrometeorological Center	Meteorological stations
1	Hydromet Center for Monitoring (city of Astana)	Astana, Borovoye, Shchuchinsk
2	Aktubinsk	Ayakkum, Novorossijsk, Mugodzhar, Shalkar, Aktobe
3	Almaty	Almaty, Kapshagai, Yessik, Minzhilki, Tekeli
4	Atyrau	Atyrau
5	East-Kazakhstan	Leninigorsk, Semipalatinsk, Ust-Kamenogorsk, Bolshearymsk
6	Zhambyl	Burno-Okryabrsk, Taraz, Tolebi
7	West-Kazakhstan	Uralsk, Aksai, Kamenka,
8	Karaganda	Karaganda, Zhezkazgan, Balkhash, Karaganda
9	Kzyl-Orda	Aral Sea, Zhusaly
10	Kostanai	Kostanai
11	Mangistau	Aktau
12	Pavlodar	Pavlodar, Irtysh, Ekibastuz
13	North-Kazakhstan	Petropavlovsk
14	South-Kazakhstan	Kazygurt, Shymkent
	Total	**38**

Observations of chemical composition of precipitation are based on the total monthly sampling of rainwater.

Sampling of snow cover is carried out once a year during the period of maximum accumulation of snow.

Observations at meteorological stations include two stages:

- sampling of precipitation and primary sample processing directly at the meteorological stations; and
- chemical analysis at a central laboratory.

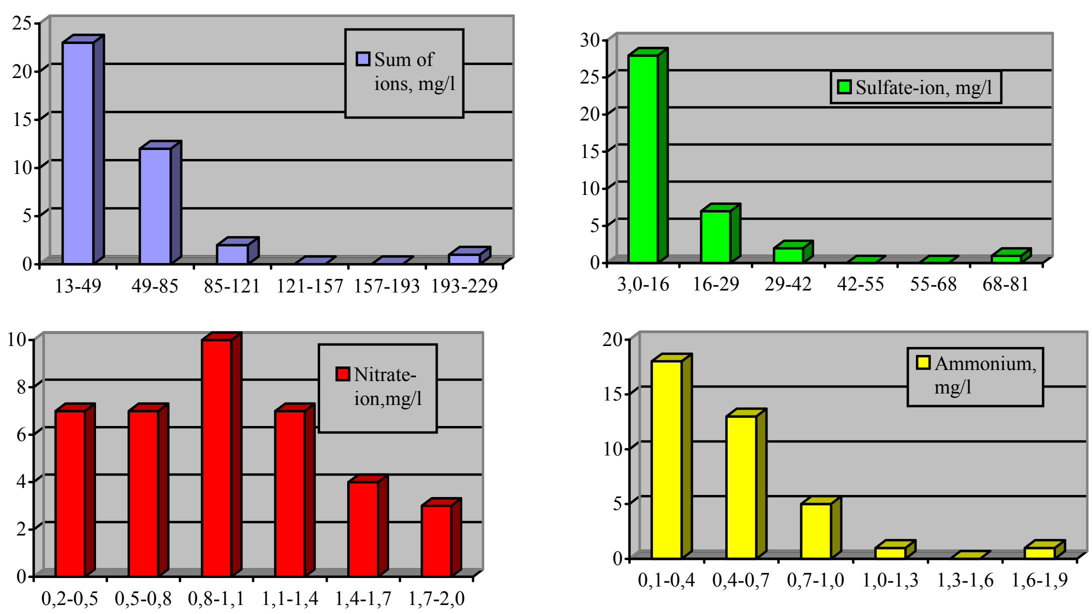
The following substances are monitored in these samples:

- anions – sulfates, chlorides and nitrates,
- cations – ammonium, sodium, potassium, calcium, magnesium; acidity and specific electro-conductivity.

According to 2002 data, the value of total mineral levels was in the range between 5.96 mg/l (Borovoye) to 225.51 mg/l (Aral Sea). In precipitation, predominant substances included: sulfates (30-35 %), hydrocarbons (25-30 %), chlorides (15-20 %), calcium ions (10-12 %) and sodium ions (7-10 %). In terms of acidity, precipitation in Kazakhstan has a prevailing alkaline character.

The distribution of specific individual substances by meteorological station (including total ions, sulfate ions, nitrate ions, and ammonium) in 2002 is shown in *Figure II-4*.

Figure II-4: *Distribution of concentrations of selected substances in precipitation, by number of meteorological stations, 2002.*



*(**Note:** vertical axes in the charts show the number of meteorological stations)*

Figure II-3: *Observational Network on Chemical Composition of Precipitation*

1.3. Background monitoring

In order to monitor the state of the atmosphere as well as other media, including interactions with the biosphere, an international network of environmental background monitoring stations, carrying out observations based on a unified program, has been established by the World Meteorological Organization (WMO).

As part of this international program, the Borovoe background monitoring station (BMS) was set up in Kazakhstan in Akmolinskaya Oblast. The station carries out observations on background pollution conditions and related biosphere trends (*Figure II-5 and Figure II-6*).

Scientific and methodological supervision of the BMS network is made by the Global Institute on Climate and Ecology (Russia), which collects, processes and analyses observational data and issues the yearly Review of Background State of Environment of the Territory of EECCA Countries (*Figure II-7*).

The following work program is undertaken at Borovoe station:

- meteorological observations;
- hydrological observations at Lake Borovoe;
- monthly precipitation sampling and conservation of samples, which are sent to the city of Almaty for determination of their content of heavy metals (lead, zinc, copper, cadmium, mercury) and their chemical composition (ammonium, sulphates, chlorides, nitrates, carbonates, sodium, potassium, calcium, magnesium, values of electro-conductivity, alkalinity, total mineralization, pH);
- snow cover sampling during the period of maximum snow accumulation (usually March) – these are sent to Almaty for the same types of analysis as precipitation samples (once a year);
- sampling of water in Lake Borovoe during the main hydrological phases (summer and winter mezhen, rise, peak and fall of spring high water) – these too are sent to Almaty for the same types of analysis as precipitation samples (4-6 times a year);
- soil sampling and preliminary processing of samples (bedding and layer of 0-5 cm) at two sites (at the end of August) – these too are sent to Almaty for analysis of heavy metals content (lead, cadmium, copper, zinc – 8 samples) and total amount of dissoluble substances in water.

According to 2002 data, the total mineral content of precipitation at Borovoe station was 15.95 mg/l. Total precipitation was 330.3 mm. Predominant substances in precipitation included hydrocarbonates (40-45 %), sulphates (20-25 %), chlorides (10-12 %) and calcium ions (15-17 %). Precipitation at the Borovoe station has medium alkalinity, pH 6.43 (Table II-5).

Table II-5: *Chemical composition of precipitation according to observational data from Borovoe meteorological station*

Precipitation, mm	Concentration of ions, mg/l									Sum of ions, mg/l	pH	Electoconductivity, mcS/cm
	Anions				Cations							
	SO_4	CL^-	NO_3^-	HCO_3	NH_4	Na^+	K^+	Mg^2	Ca^{2+}			
330.3	3.50	1.84	0.72	5.24	0.34	0.80	0.63	0.56	2.31	15.95	6.43	28.2

Figure II-5: *Location of the Background Monitoring Station BOROVOE*

Figure II-6: *Background Monitoring Station BOROVOE*

Figure II-7: *Scheme of location of observational network of background monitoring*

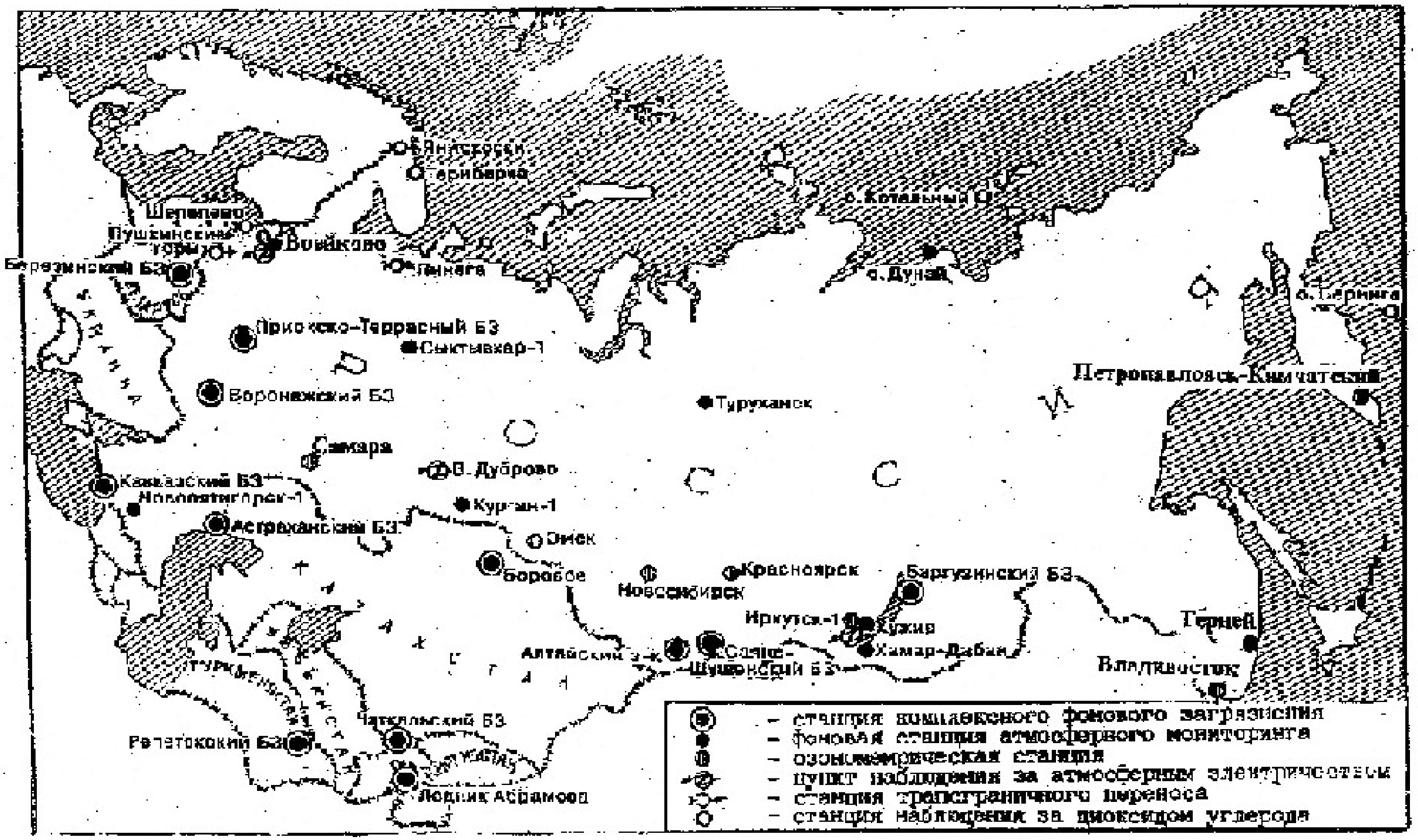


Рис. 6. Карта-схема размещения наблюдательной сети фонового мониторинга

1.4. Air pollution modeling

1.4.1. Regional environmental problems

The location of Kazakhstan, in the center of the Eurasian mainland, defines the specific features of its environmental conditions. For example, the atmosphere over considerable parts of its territories has a low potential resistance to pollution by gaseous substances.

During the country's development, large territorial and production complexes were built without taking into consideration their impact on environment. The main air pollutants of industrial cities are enterprises in the energy and metallurgy sectors; outside industry, urban transport generates 40-60% of harmful emissions.

Across the territory of Kazakhstan, three main zones have the highest anthropogenic loading of priority environmental problems:

Zone A – Caspian Sea zone. Here there are enterprises specialized in oil and gas extraction and processing. The priority problem is hydrocarbon environmental pollution.

Zone B – Eastern. This is one of most highly developed industrial regions, with a concentration of large enterprises for ferrous and non-ferrous metallurgy and energy production. Problems of solid industrial waste and urban air pollution are predominant here.

Zone C – Southern. This area is characterized mainly by agricultural production, which requires sustainable water supply. Lack of water, wastewater pollution and pasture degradation are sharply evident. Industrial and energy enterprises contribute significantly to the air pollution of the zone, coupled with the orographic influence on substance dispersal that can cause dangerous concentrations of pollutants in the air.

Table II-6: *Values of maximum admissible concentrations of selected pollutants in ambient air of populated areas in the Republic of Kazakhstan*

Ingredients	Values of MAC, mg/m^3		Class of hazard
	One-time maximum	Daily average	
Carbon monoxide	5.0	3	4
Nitric oxide	0.4	0.06	3
Nitric dioxide	0.085	0.04	2
Dust (suspended substances)	0.5	0.15	3
Phenol	0.01	0.003	2
Formaldehyde	0.035	0.003	2
Lead	0.001	0.0003	1
Ammonia	0.2	0.04	4
Sulphur dioxide	0.5	0.05	3
Hydrogen sulphide	0.008	-	2
Chlorine	0.1	0.03	2
Ozone	0.16	0.03	1
Hydrogen fluoride	0.02	0.005	2
Copper	0.003	0.001	2
Hydrogen chloride	0.2	0.1	2

The state of air pollution in populated areas is estimated using the results of the analysis and processing of air samples taken at stationary observational posts. The main quality criteria are the values for maximum admissible concentrations (**MAC)** of pollutants in the ambient air of populated areas (*Table II-6*). The level of atmosphere pollution is estimated based on value of the atmosphere pollution index (**API_5**), which is calculated using the five substances with the highest values, rated against **MAC,** taking into account the class of their hazard.

Analysis of the observational data indicates a rather high level of atmospheric air pollution in cities and industrial centers of the country, despite the reduction in air emissions due to the decline in industrial production in recent years. The situation is further aggravated by the increase in the number of private vehicles, in particular obsolete car models, compounded by the use of low quality gasoline.

According to 2002 data, in terms of average annual values for the concentrations of pollutants, at least one ingredient exceeded MAC in 17 cities of the country, and in five cities concentrations of three and more ingredients exceeded MAC. Average annual concentrations of suspended particles (dust) between 1.3 and 2.7 MAC were observed in 8 cities; those of nitric dioxide (1-3.0 MAC) in 12 cities; sulphur dioxide (1.1-2.5 MAC) in 4 cities; formaldehyde (1.0 – 4.3 MAC) in 9 cities; and phenol (1.4-3.6 MAC) in 6 cities.

Maximum one-time concentrations of pollutants – for at least one substance exceeding MAC – were observed in all cities where observations are carried out. In 12 cities, three or more pollutants exceeded MAC. Levels above MAC were observed for the one-time concentrations of dust (17 cities), nitric dioxide (19 cities), carbon monoxide (9 cities), phenol (7 cities), and formaldehyde (5 cities).

Table II-7: *Priority list of cities of the Republic of Kazakhstan in terms of level of atmospheric air pollution*

	City	API_5			Industry sectors with an impact on air pollution
		2000	**2001**	**2002**	
1	Ust-Kamenogorsk	17.8	14.2	16.0	Non-ferrous metallurgy, energy
2	Almaty	9.9	13.1	11.7	Energy, urban transport
3	Glubokoyer village	14.4	10.2	11.5	Non-ferrous metallurgy
4	Ridder	10.0	10.3	11.3	Non-ferrous metallurgy, energy
5	Aktobe	10.0	8.5	9.5	Ferrous metallurgy, chemical industry
6	Shymkent	10.0	11.8	9.5	Non-ferrous metallurgy, chemical industry, oil processing
7	Temirtau	6.9	7.8	8.8	Ferrous metallurgy, chemical industry
8	Taraz	7.8	6.7	7.3	Chemical industry
9	Zhezkazgan	7.5	7.9	6.8	Non-ferrous metallurgy, energy
10	Karaganda	4.6	4.6	6.5	Energy, coal mining, urban transport
11	Aktau	4.6	4.4	4.8	Chemical industry
12	Kostanai	2.9	3.2	3.4	Energy
13	Petropavlovsk	6.8	5.1	3.4	Energy, instrument-making industry
14	Astana	2.7	1.3	2.6	Energy, urban transport
15	Semipalatinsk	4.0	3.3	2.6	Energy, construction materials
16	Balkhash	3.3	2.2	2.4	Non-ferrous metallurgy, energy
17	Atyrau	2.5	1.8	2.0	Oil processing
18	Ekiastuz	1.7	1.4	1.9	Energy, coal mining
19	Pavlodar	2.3	2.7	1.5	Oil processing, energy
20	Uralsk	1.4	1.2	1.2	Energy
	Average	**6.56**	**6.09**	**6.24**	

Ten cities are considered polluted (with API_5 exceeding 5), including eight with high levels of air pollution (with API_5 exceeding 7), of which one city – Ust-Kamenogorsk – is considered to have a very high level of air pollution (with API_5 equal to 16). For other cities, values of API_5 are within 1.3 to 2.3 (*Table II-7*).

The main factors determining the long-range and transboundary transport of pollutants are: emissions volume, character of distribution of these substances and of the products of their transformation in the atmosphere, their subsequent migration in other mediums (water, soil, biota), and their impact on nature processes.

The most important major parameter affecting the scale of pollutant dispersion in the atmosphere is average duration in the atmosphere. The degree of pollutant impact on the environment and biota depends on the concentration as well as on the individual physical properties of pollutants and the products of their transformation.

Based on these prerequisites, it seems possible to distinguish between three main types of air emissions affecting transboundary pollution:

- emissions that lead to global-scale pollution;
- emissions that lead to pollution on a regional scale (across the territories of several or many countries);
- emissions that create pollution on a local scale, i.e. causing negative consequences on relatively small territory, for example on bordering areas of two neighboring countries.

It should be mentioned that often no distinct dividing line may exist between these three types, especially between regional and local pollution.

The first type of emissions includes emissions of substances with a long duration (as a rule, gas-type substances). For this reason they are able to disperse relatively evenly on a global scale regardless of the site of their emission. Such gases include specifically carbon dioxide, freons, and the radioactive gas Krypton-85. Strong nuclear explosions can disperse radioactive products to the stratosphere, and global pollution with these products occurs if their life time is equal to one month or even less. From among this type of substances, only carbonic acid (formed from carbon dioxide) has an influence on the acidity of precipitation.

The second type includes emissions of substances that have a limited duration in the atmosphere and are capable of significantly contributing to the pollution of a large region. Outside this region, pollution levels relatively quickly fall, although in small, often trace concentrations, most of these substances can be found throughout the globe. The most typical representatives of this group of pollutants are substances that cause the acidification of precipitation: sulfur and nitrogen compounds, pesticides and heavy metals (first of all mercury).

The third type includes emissions of substances that create local pollution on the territory of individual countries with common borders. Here, the relatively small scale of phenomena reflects the short duration in the atmosphere of certain substances (roughly dispersed aerosols, hydrogen sulphide etc.) or low-level emissions from small sources of substances mentioned under the second type, including sulphur and nitric oxides.

1.4.2. The role of meteorological factors in transfer and dissipation of pollutants in the air

The transfer and dispersal of substances emitted into the atmosphere takes place according to the laws of turbulent diffusion, and the duration of ingredients in the atmosphere depends on many factors, the dominating ones being meteorological factors:

- wind regime (wind direction and speed),
- temperature stratification conditions in the lower atmospheric layers,
- intensity of solar radiation (influencing photochemical reactions and the formation of by-products),
- air temperature, which has both a direct and an indirect influence, via precipitation.

In addition, the following atmospheric processes take place:

- Gravitational deposition of large particles;
- Chemical and photochemical reactions between different substances;
- Long-distance transportation and removal from the atmosphere by precipitation.

Under the influence of all these factors, the level of near-surface layer pollution during continuous air emissions may fluctuate within rather wide ranges. In connection with this, the task to preserve the purity of the air in cities depends to a considerable extent on understanding of the role of meteorological factors and on considering the ability of atmosphere to dissipate and remove harmful substances emitted, i.e. ability of atmosphere for "self-purification".

As it disperses in the atmosphere, a pollutant undergoes processes of both wet and dry deposition as well as chemical transformation. To estimate the process of dry deposition, it is necessary to determine the portion of the pollutant emitted that is removed from the atmosphere during dispersion. Dry removal of substances is defined by factors such as vertical turbulence, their interaction with the surfaces of other substances, and gravitational deposition.

The main factor affecting the dispersion of substances in the atmosphere is the wind regime. A number of elements influence wind effects: location of emission sources, topological reliefs, local circulation, influence of objects themselves on the wind regime, as well as interrelations among these factors.

The influence of wind speed on pollutant concentrations is reflected in two ways. On the one hand, stronger winds stimulate the dispersion of substances in the atmosphere: obviously, strong winds at the both surface levels and higher levels cause the removal of the entire mass of polluted air outside the local area and cleanse the air basin. On the other hand, weak winds result in an increased rise of heated emissions, especially during calm conditions, and consequently a reduction in concentrations in the surface air layer.

Temperature stratification in lower atmospheric layers also influences the evolution of concentration. Continued thermal stratification, together with wind speed, has an impact on pollution levels. Commonly, higher levels of air pollution are observed in cities under conditions of both surface and higher thermal inversions. With surface level inversions, small source emissions accumulate near the surface, whereas under conditions of higher inversions, vertical dispersion is limited. Investigations have shown that one of the conditions for forming high ambient pollution levels in cities is a combination of calm winds and surface-level inversion, i.e. a combination of parameters called a "stagnation situation".

The intensity of solar radiation plays an important role in the formation of air pollution. Under intense solar radiation, photochemical reactions occur, causing the formation of various by-products that often have more toxic properties than the substances coming directly from emissions sources. Thus, in the process of photochemical reactions in the atmosphere, there is an acidification of sulphur-based gases and the formation of sulphate aerosols. Typically, photochemical reactions can occur in the atmosphere under the influence of solar radiation at relatively low initial pollution concentrations, creating the potential for the formation of high levels of air pollution.

Air temperature has direct or indirect influence on the content of ingredients in the atmosphere. Fuel consumption for domestic heating changes depending on the temperature, implying changes in concentrations of harmful air emissions. Air temperature is also an important factor in photochemical reactions: the higher the temperature, the quicker the reaction.

With decreasing temperatures, the effect of local circulation becomes stronger, causing relatively clean air from the outskirts to move towards a city center. In addition, at lower temperatures, the temperature difference between emissions and surrounding air increases, leading to a higher vertical rise of pollutants and a reduction of their influence on the surface atmospheric layer.

Precipitation helps cleanse the atmosphere. The intensity of precipitation plays an important role. The rate of removal of sulphur-based gases increases with increasing rain intensity. The concentrations of nitric dioxide as well as those of sulphur-based aerosols fall with precipitation, and ozone and other oxidizers almost completely disappear from the atmosphere after rain in summer time.

1.4.3 Modeling at urban scale. Integrated assessment of pollution levels.

To **forecast unfavorable meteorological conditions,** a method developed at the A.I. Voeikov Main Geophysical Observatory in Russia, by L.R. Sonkin, is applied. An **integrated indicator (parameter P)** of air pollution is used in this method. It is defined using both separate substances and groups of substances.

Critical parameter values have been calculated on the basis of long-term data to define the extent of air pollution. Statistical processing for the whole time series of calculated values for all seasons of the year has been carried out separately. The selection of predictors is usually made from among the general physical assumptions on possible reasons for change of substance concentrations: change in wind direction or speed, stability of the atmosphere, washing or transformation of ingredients, etc. Some qualitative conclusions from atmospheric diffusion theory are being used, including those on the influence of retarding layers in the borderline atmospheric layer.

The value of **parameter P** is determined for both individual substances and groups of substances:

$$\mathbf{P = m/n,}$$

where **n** = total number of observations in a city during one day;

m = number of observations during the same period of time with concentrations 1.5 times or higher above the average seasonal amount, which for each season is calculated as the average of three monthly average concentration values.

On the basis of multi-year data, critical parameter values have been calculated, defining the extent of air pollution. Statistical processing for the whole time series of calculated values of **parameter P** by gradations, for each season of the year separately, has been carried out. The following value gradations of **parameter P** may be distinguished:

- low (<0.21);

- relatively high ($0.21 \leq P \leq 0.35$);
- high (> 0.35);
- very high (> 0.45).

Periods with high air pollution levels conventionally include periods when the value of parameter $P > 0.35$ is observed continuously during three and more days.

The value of parameter P is viewed as a predictant, and on the basis of statistical processing it is linked to predictors: wind speed, atmospheric stability etc. Accounting for synoptic processes is especially important during the analysis and forecasting of long periods (3 and more days) with high air pollution.

Using this method, the occurrence of unfavorable meteorological conditions is forecast for the cities of Almaty and Ust-Kamenogorsk and for Buhtarma village (in East-Kazakhstan oblast).

Forecasts of unfavorable meteorological conditions are made for the purpose of warning of high and extremely high air pollution levels. There are three degrees of warnings:

– the first degree, when the expected level of air pollution is above critical;

– the second degree, when after a warning of the first degree, further information shows that measures taken do not ensure reduction of air pollution levels;

– the third degree, when after notification of the second degree, high air pollution levels remain.

Forecasts of unfavorable meteorological conditions are made taking into account operational data from Kazhydromet's air pollution monitoring laboratories.

Currently, the group in Kazhydromet on forecasting unfavorable meteorological conditions is starting to test a COFAP model (Current Objective Forecast of Atmospheric Pollution), which incorporates a comprehensive experimental and theoretical study of air pollution of Almaty city. The model was developed at the Institute of Space Research. Project research relates to the program ANAPC-87 (Analysis of the Atmospheric Pollution of the City), including a theoretical package of models and COFAP system software.

1.4.4. Monitoring and modeling of soil and dust storms in the area the Aral Sea (Priaralye)

The Aral Sea tragedy has had a whole series of negative consequences – from the decline of fauna to the onset of a drier climate. The wind regime of Priaralye has changed significantly: there are now frequent storms accompanied by the carryover of huge amounts of sand and salt from the dry bed of the Aral Sea. These dust storms are the triggering mechanism for the desertification of large areas near the Aral Sea. Aerosol carryover has a transboundary character, affecting practically all Central Asian countries and Russia. The problem is further aggravated by the ongoing disappearance of the Aral Sea and the continuous formation of new centers of aerosol carryover.

Surface observations have, as a rule, limited character, since they can not cover the whole territory. In addition, they are quire labor-intensive and costly as a result of the extremely unfavorable conditions on the Aral Sea's dry bed. However, mathematical models adjusted to current conditions allow the assessment of factors such as the amount of aerosols transported, the distance of their flow, and the amount of particles deposited.

Dust storms and ground winds in the Aral region are caused by unfavorable meteorological conditions and surface conditions.

Meteorological conditions linked to the development of deflationary processes include high wind speeds, low atmospheric humidity and low precipitation.

The average wind speed at the island stations is 6-7 m/sec, and on nearby mainland, 3-4 m/sec. Strong winds are quite frequent in the Aral Sea region, especially on the west coast of the sea.

The largest part of Priaralye's territory is formed by sands and soils of light mechanical composition. The composition of sands leads to the development of a rare vegetation cover.

These natural factors define the high vulnerability of the territory to deflationary processes in the form of sand storms and ground winds. Storms and ground winds are most frequent in Northern Priaralye, where their multi-year recurrence reaches 36-84 days a year.

General principles of model building

For the system of sand storm monitoring in Priaralye, the Institute of Space Research of the Ministry of Education and Science of the Republic of Kazakhstan has developed the main structural elements for modeling subsystems and the framework limitations imposed by information flows.

Modeling on a consolidated basis is built of three blocks: input information, processing, and outputs. The input and output information blocks are dictated by the overall construction of the system; the output base is designed for a rather free presentation of data depending on the task being solved. The main input and output formats are maps, although there may be tables, results of graphical analysis, descriptions, etc.

For the calculation of aerosol rise and transport from the dry bed of the Aral Sea, main and auxiliary models have been built. These are in the form of special subprograms in the block of processing procedures. On this basis, modeling for the whole process is built.

The process consists of two stages:

- *primary processing,* which includes the process of preparation of spatial input data through vectorization and GRID-transformations. This stage is necessary in preparation of data required for mathematical modeling. Geographic information in digital form with required attributes has been obtained by cartographic modeling.
- *the modeling process* itself, which provides for consecutive calculations of the rise and transport of aerosol particles.

The model hierarchy consists of the following main stages:

1. Calculation of disperse structure of sand surface
2. Calculation of critical dynamic flow speed
3. Calculation of the capacity of surface source (mass flow)
4. Calculation of the sand storm tail.

Dispersal structure of the sand surface and values of critical dynamic flow speed are used during calculation of source capacity. The obtained value of source capacity is an output for the calculation of substance transport in the sand storm tail.

Geo-informational modeling envisages the use of the programming language Arc Marco Language (AML). This language allows the construction of thematic GIS-applications using geo-processing operations of the program module Arc Info Workstation.

The applied dust storm model for Priaralye has allowed:

– the construction of a classification of intensity of dust storm origin centers; calculation of aerosol carryover under various wind speeds;

– the creation of a dust storm tail model;

– comparison of modeling results with remote sensing data.

1.4.5. Modeling of air pollution in Almaty city

Within the UAP project, modeling of air pollution in Almaty city from urban transport has been carried out by the Institute of Space Research of the Ministry of Education and Science of the Republic of Kazakhstan (2002).

Modeling and monitoring of air of Almaty city is necessitated by extremely unfavorable conditions of pollutant transport and dispersal. These conditions include:

1. Weak circulation of wind (according to multi-year observations, the average wind speed does not exceed 2-3 m/sec.; recurrence of calms is up to 40 %).
2. Weak turbulent mix (vertical turbulent diffusion is not more than 0.5 m^2/sec.).
3. Presence of intensive inversion layers (in winter time recurrence of surface layers reaches 90%; and elevated layers, 70%).

Alongside this, the major increase in the number of vehicles in recent years, together with emissions from power and heating stations as well as those from heating systems for domestic housing located within the city, account for high emissions of gas and aerosol pollutants in the city.

Model software included:

– cartography block. Mapping of the territory of Almaty city was completed using remote sensing data;

– data on wind fields in conditions of mountainous and valley circulation;

– data on inversions (lower border of inversion layer);

– data on emissions transport.

The statistical model of the city's daily average air pollution, MoDAP, was applied as a calculation model.

Calculations were made for the following pollutants: CO, NO_x, Pb, C_6H_6, PM, SO_2.

The mathematical models were verified using the following data:

- hourly dynamics of the territory's average concentration of CO;
- hourly dynamics of the lower border of the inversion layer; and
- hourly dynamics of annual average intensity of urban transport traffic.

The final results of dynamics for carbon monoxide concentrations show that there is a continuous emission source in the central part of the city, where the intensity of traffic is at a maximum and where a large number of small and medium enterprises are located, i.e. where a maximum pollution “hot spot” is permanently present.

At 3 a.m., isoclines of carbon monoxide concentrations stretch from south-west towards north-east, and after 9 a.m., substance dispersal starts. After sunrise and during daytime, tails from the main sources follow the direction of wind flows, and the dominant direction of isoclines of concentration is south-west and north-east.

Based on close correspondence between observations and calculated data, calculations for other ingredients may be made rather confidently.

Three scenarios have been calculated during modeling:

- *current state*
- future state – *pessimistic forecast*
- future state – *optimistic forecast.*

This numerical model within a geographic information system was adjusted to the climatic and anthropogenic conditions of Almaty city, which is located in a mountainous area. Application of this model in future for other territorial areas involves a preparation stage, with the development of meteorological forecasting and classification of the meteorological situation, obtaining detailed fields of meteorological elements in space and time. Completed calculations and model verification for such a difficult territorial object as the city of Almaty make it possible to state that grounds have been laid for the creation of a model system, applying highly precise methods and modern geo-informational technologies.

2. The EMEP Monitoring Program

The following documents of the Executive body on the Convention on Long-Range Transboundary Air Pollution have been used as the basis for this description of the monitoring program:

Work Plan for 2002 and Proposed Priority Tasks for the Period up to 2004 (25 th Session, Geneva, September 3-5, 2001)

Work Plan on Implementation of the Convention on Long-Range Transboundary Air Pollution in 2002 (19th Session, Geneva, December 11-14, 2001)

Work Plan on Implementation of the Convention on Long-Range Transboundary Air Pollution in 2002 (20th session, Geneva, December 10-13, 2002)

The following work elements currently are being implemented within EMEP, in close cooperation with the Parties to the Convention and national experts, as well as other environmental protection programs and projects:

- Emissions – up-dating the EMEP emission inventory based on data submitted by Parties to the Convention;
- Atmospheric measurements and modeling – assessment of the results of implementation of the Protocols to the Convention and development of atmospheric measurements and modeling tools and provision of support in this work;
- Development of models for comprehensive evaluation – analysis of scenarios for cost-effective reduction of acidification, eutrophication, tropospheric ozone, particulate matter (PM) pollution and related phenomena, including POPs and heavy metals pollution;
- Acidifying and eutrophying compounds – providing monitoring and modeling data on concentrations, depositions and transboundary fluxes of sulphur and nitrogen compounds over Europe;
- Photo-oxidants – providing monitoring and modeling data on concentrations and transboundary transport of ozone, NO_x and volatile organic compounds, and evaluation of short-term and long-term exposures to photochemical oxidants;
- Heavy metals – providing monitoring and modeling data on concentrations, depositions and transboundary fluxes of cadmium, lead and mercury;
- Persistent organic pollutants (POPs) – improvement of monitoring and modeling data on concentrations, depositions and transboundary fluxes of selected POPs and further study of physical and chemical processes of POPs in different environmental compartments, taking into account their transport within the EMEP region and on the hemisphere/global scale;
- Fine particulates – providing an evaluation of concentrations, transboundary fluxes and cost-effective strategies to combat air pollution with particulate matters, development of emissions inventories.

The following criteria should be taken into account during EMEP monitoring:

Representativeness within the region

The site chosen for sampling and measurements should be representative of a larger area, the size of which is determined by the variability of the air and precipitation quality, and the desired spatial resolution in the concentrations and deposition field. Urban and industrial areas, and the areas immediately outside such areas, are not to be included in the measurements program, because these make up a very small fraction of the total area covered by EMEP and the higher concentrations in such areas are caused by national emissions.

The purpose of EMEP monitoring is to provide information on the deposition and concentration of air pollutants, as well as on the quantity and significance of long-range transmission of pollutants and fluxes across national boundaries.

The area of the representative site should be larger than the size resolution of the atmospheric dispersion models which are available for the evaluation of long-range transmission and deposition of air pollutants. EMEP models and emission surveys have up to now employed grid sizes of 150*150 km^2, and this spatial resolution is now being improved to 50*50 km^2 in some models.

When the major part of the emissions influencing the air quality in an area are situated outside that area, selection of the site mainly involves consideration of the effects of the immediate surroundings and emissions within the nearest 20 km. In addition, consideration of local meteorological conditions, such as prevailing wind directions and formation of stagnant air, should be considered.

The situation is more complicated if the site is located within an area of major emissions. In principle, the representativeness of a particular site within such an area can be determined by the use of models. Sites within areas with large emission sources should therefore be expected to be representative only on a monthly or yearly averaging period.

At present, a minimum distance is defined for emissions accounting (*Table II-8*). These data were based on a similar monitoring program in North America.

Table II-8: *Minimum distance to emission and contamination sources*

Type	Minimum distance	Comment
Large pollution sources (towns, power plants, major motorways)	50 km	Depending on prevailing wind directions
Small scale domestic heating with coal, fuel oil or wood	100 m	Only one emission source at minimum distance
Minor roads	100 m	Up to 50 vehicles/day
Main roads	500 m	Up to 500 vehicles/day
Application of manure, stabling of animals.	2 km	Depending on the number of animals and size of fertilized field or pastures
Grazing by domestic animals on fertilized pasture	500 m	Depending on the number of animals and size of fertilized field or pastures

The distances given in this table should be taken only as indicative, and an appraisal of local emissions' influence on the air and precipitation chemistry at the site must be made on the basis of considerations of meteorological and topographic conditions.

Representativeness with respect to topographic features.

The site must be representative also with respect to exposure to the air mass. Valleys or other locations which are subject to formation of stagnant air under inversion conditions should be avoided, and also mountaintops and passes (cols). The ideal is a well exposed site in moderately undulating terrain, or, if valleys cannot be avoided, on the side of the valley above the most pronounced night-time inversion layer.

Coastal sites with pronounced diurnal wind variations due to land-sea breeze effects are also not recommended. Vegetation is a sink for many air pollutants, and it is important to avoid situations sheltered by vegetation.

The choice of a site and the proper location of the precipitation collector are also important in order to ensure that the precipitation samples are representative for precipitation over a larger area. The collector should not be exposed to strong winds, but should also not be sheltered by tall trees or buildings. The annual precipitation amount at the site, as measured by an ordinary meteorological precipitation gauge, should not differ markedly from the precipitation amounts at adjacent sites in the national precipitation network, and the daily precipitation amounts should also be correlated with those from the adjacent sites.

The location of the sampler should conform to WMO site requirements for precipitation gauges (WMO, 1971). There should be no obstacles, such as trees, higher than 30m above the rim of the precipitation collector, and buildings, hedges, or topographical features which may give rise to updraughts or downdraughts should be avoided. Consideration of the prevailing wind directions during precipitation events is recommended in connection with locating the sampler.

Of particular concern is potential contamination from sedimentation of soil dust particles from the immediate surroundings. Gravel roads, farmyards, and tilled agricultural fields within a distance of 100 m to 1 km should be avoided. The ground cover should preferably be short grass.

Technical facilities

Air sampling and monitoring equipment requires a small building, or shed, and supply of electricity. The room containing pumps and control units should preferably be kept at approximately 20^{o}C. A refrigerator must also be available for storage of samples. A telephone line is useful for the transfer of ozone measurement data via a modem from a data logger. Access to the site by car should be limited to the persons directly in charge of the sampling and the measurements.

The land use, and the topography of the immediate surroundings, and preferably also the meteorological conditions (wind rose, climatological data) should be available in the form of maps, tables and diagrams. An inventory of emissions in the nearest 20 km is also required.

In order to evaluate the representativeness of the site, information on the air quality and deposition for several sites within the same area is generally required. Such information may be provided by detailed mathematical modeling if the sources of air pollutants are known in sufficient detail.

Simple and relatively inexpensive measurement techniques are now available for the determination of long-term average concentrations of sulphur dioxide, nitrogen dioxide and ammonia, using passive samplers. For precipitation, weekly or even monthly sample collection at a number of sites within the same area will serve to determine the representativeness of the chosen site.

The ***EMEP measurement program*** includes observations for gases, particles and precipitation (*Table II-9*).

Table II-9: *EMEP measurement program for 2003*

	Components	Notes	Measurement period	Measurement frequency
Gas	SO_2		24 hours	daily
	NO_2			daily
	HNO_3			daily
	NH_3			daily
	O_3		Hourly means stored	continuously
	Light hydrocarbons C2-C7		10-15 min	twice a week
	Ketones and aldehydes		8 hours	twice a week
	Hg		24 hours	weekly
Particles	SO_4^{2-}		24 hours	weekly
	NO_3^-		24 hours	daily
	NH_4^+		24 hours	daily
	Na, Mg, Ca, K (Cl)	*	24 hours	daily
	PM 10	*	24 hours	daily
	PMx (2,5 or 1,0)	**	24 hours	daily
	Mineral dust		24 hours	daily
	Elemental and organic carbon	*	24 hours	daily
	Organic carbon specification		weekly	weekly
	Cd, Pb (priority); Cu, Zn, As, Cr, Ni (additional)		24 hours	once a week
	Chemical specification as function of PM size		24 hours	daily
	Number size distribution		hourly mean stored	continuously
	Light scattering		hourly mean stored	continuously
Gas and particles	$HNO_3(g)+ NO_3^-(p)$		24 hours	daily
	$NH_3(g)+ NH_4^+(p)$		24 hours	daily
	POPs (PAN, PCB, HCB, chlordane, lindane, a-HCH, DDT/DDE)		to be decided	to be decided
Precipitation	Amount, SO_4^{2-}, NO_3^-, Cl, pH, NH_4^+, Na^+, Mg_2^+, Ca_2^+, K^+, conductivity		24 hours/ weekly	Daily weekly
	Hg, Cd, Pb (priority); Cu, Zn, As, Cr, Ni (additional)		weekly	weekly
	POPs (PAN, PCP, HCB, chlordane, lindane, a-HCH, DDT/DDE)		to be decided	to be decided

Notes:

* The recommendation to measure PM10, elemental carbon, organic carbon and soluble base cations at all EMEP sites may not be feasible in the short run. However, measurements should be started at as many sites as possible and on at least one site in each country.

** As a European reference method for PM2.5 is not expected before 2004, countries are encouraged to start their measurements using other available methods.

Requirements for monitoring of heavy metals and POPs.

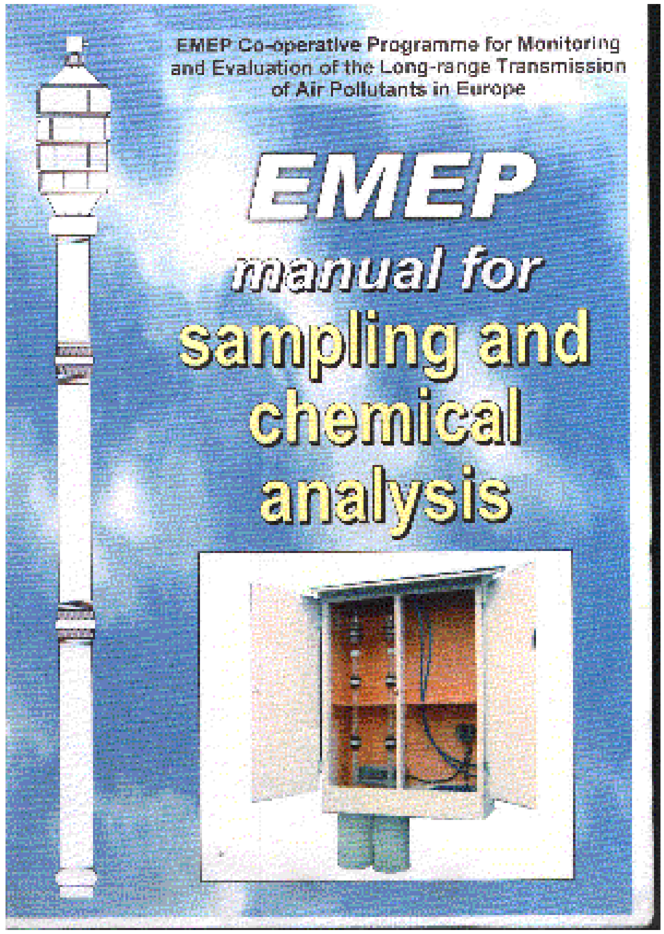
For the verification of the model and construction of model parameters, it is desirable to have:

- Measurements in different points of the northern hemisphere (specifically, in the north-western and southern parts of Kazakhstan) on at least a monthly basis;
- Measurements in different media (atmosphere, soil, vegetation, sea water);
- Simultaneous measurements in various media (atmosphere and soil, atmosphere and vegetation etc);
- Separate measurements of the gas and aerosol phases of pollutant;
- Measurements of the individual components of POPs and various forms of mercury;
- Characteristics of data representativeness and quality;
- Meteorological information on the site of location of the station.

In 1996, the EMEP Manual for Sampling and Chemical Analysis (Figure II-8) was developed and published by the EMEP Chemical Coordination Center. The Manual contains the following sections:

1. Introduction
2. Siting criteria
3. Sampling methods
4. Chemical analysis
5. Quality assurance
6. Data handling and data reporting

Figure II-8: *EMEP Manual for Sampling and Chemical Analysis*



Unfortunately, application of this Manual in Kazakhstan is difficult due to the lack of a Russian version.

Priority directions for cooperation with EMEP international centers are as follows:

- Methods and methodologies for work on elements of EMEP monitoring program;
- Trial and introduction of the main provisions of EMEP Manual on Sampling and Chemical Analysis;
- Participation in the international programs of EMEP centers (modeling of transport and verification of the models, intercalibration of laboratories, standard samples, information on instruments and equipment etc.).
- Participation of national specialists in the training programs and projects of EMEP Centers.

3. Issues for the Implementation of the EMEP Monitoring Programme in Kazakhstan.

To carry out EMEP monitoring in Kazakhstan in current conditions, it is necessary to implement practical activities in several directions.

Funding to ensure the functioning of the monitoring program should be provided through the national Budget. Involvement of targeted international grants is possible.

Funds of the national Budget are fixed on the basis of targeted national programs and are spent, based on state orders for:

- the creation and support of functioning of monitoring programs;
- the creation of scientific and technical products to ensure monitoring functions and development.

The ***Legislative base*** should be oriented towards the development of a legal base and optimization of the management structure, to minimize costs and allow the efficient implementation of monitoring tasks. This involves development and adoption of legal and regulatory acts and documents regulating status of EMEP monitoring in the Unified State System of Environment Monitoring.

The ***Regulatory base*** should provide for the development of specialized standards for the implementation of the monitoring program.

The regulatory function also includes the development and introduction of packages of normative documents that regulate requirements, rules and procedures adopted for the creation and organization of the EMEP monitoring system, its structural subdivisions and their elements.

Methodologies are aimed at the creation of a scientific basis that will ensure completeness and accuracy of monitoring tasks. Methodologies should solve problems of task interconnections and define possibilities and limits for the application of methods, algorithms and modeling programs. Methodologies should be developed through the preparation and implementation of scientific research on principles and rules for the implementation of specific work.

Technical documents are needed to create the methodological base required for monitoring system functioning. The main task is the organization of the development and introduction of technical documents to obtain comparable results for observations, assessments and forecasts regardless of the place and time of their implementation.

Technical documents shall be based on the set of mandatory requirements that define procedures and rules for monitoring organization and implementation.

The ***Information base*** includes common rules and protocols for information exchange and for systems and means of telecommunication. The organization of data sharing provides for development of sharing protocols, uniform formats for messages, uniform scale of priorities and unified software, as well as requirements for technical means, ensuring interrelations among data bases and information centers.

The information base involves the development of structures of information systems, database systems, classifiers, data vocabularies and unified forms of input and output documents. For effective information sharing, a single methodology for data collection and processing should be used, as well as common technical means, hardware and software to share information at all levels.

Software is required, including algorithms to implement the goals and tasks of monitoring. It shall be designed as a spreadsheet system of data processing, with sets of air pollution estimation and projection models, pollutant migration and transformation models, measurement models, models on defining emissions sources and other models required to solve monitoring tasks.

Software allows the automated resolution of such tasks as the estimation, diagnostics, classification and forecasting of air pollution, including transboundary air pollution; updating of distributed data bases; modeling of emergency situations and their potential consequences; and the development of recommendations for making operational decisions.

Software procurement shall be open and ensure the inclusion of newly developed applications programs.

Equipment and instruments for unified information and measurement, as well as information and computing systems and telecommunication systems, include:

- information and measurement systems required to solve monitoring tasks (under normal and emergency conditions);
- portable, mobile and stationary laboratories for the analysis of different types of air pollution;
- aerial and space means to make large-scale photographs of localities, observe polluted air mass transport and landscape changes;
- sets of sample collection and measuring devices; sets for information storage, processing and transfer;
- telecommunication systems ensuring efficient data transfer.

Equipment and instruments are used to carry out monitoring functions for the observation, collection, processing, transfer and reproduction of data.

Metering is ensured in close cooperation with metrological subdivisions of Gosstandard of the Republic of Kazakhstan and is oriented toward the maximum use of its base.

Metering activities include:

- development of normative documents, regulating general procedures and rules to ensure the uniformity of measurements and the comparability of the results in the implementation of the EMEP monitoring program;
- organization of metering for observations;
- metrological expertise in regulatory and methodological documents and programs for monitoring;
- control of metering in the subdivisions which carry it out;
- collection and storage of information on monitoring and metering.

Individual offices that carry out EMEP monitoring shall interact and supplement each other. The activity of any of the functional blocks of monitoring is supported, as a rule, by several types of monitoring , and each of the types of monitoring supports all or several functional blocks.

4. Priorities for the development of EMEP monitoring programme elements in Kazakhstan

The following priority directions have been identified for developing elements of the monitoring program in Kazakhstan:

- Establish a pilot project to review the EMEP Manuals on carrying out measurements in the air pollution monitoring program. Translate and agree on these guidelines.
- Review existing air pollution models and test their use in Kazakhstan.
- Train national experts and encourage their participation in international training courses.
- Develop a medium-term plan of activities aimed at setting up and carrying out the EMEP monitoring program in Kazakhstan, including the optimization of the observation network, approval of and agreement on the observation and measurement program, methods of chemical analysis, recommendations on instruments and equipment, analysis and processing of observations and measurements data, information exchange.
- Cooperate with the EMEP Centers on improving the regulatory, methodological, technical and information basis for monitoring;
- Develop measures and activities to set up and implement elements of the EMEP monitoring program in Kazakhstan.

The following measures should be implemented to develop the EMEP monitoring program in Kazakhstan:

- optimization of the observational network for environmental monitoring through the identification of stations for monitoring elements suggested under the EMEP monitoring program;
- technical upgrading and modernization of equipment in monitoring stations and in chemical and analytical service facilities;
- equipping central and network services with modern communication means (modems, PCs, software, photocopying and copying machines) and with facilities for the automated processing of data obtained from monitoring related studies;
- develop a unified, automated information system, using software to collect, process and store information on a common methodological basis, as well as to ensure the exchange of environmental information between various levels of government and data bases using standardized formats.

5. Recommendations on air pollution monitoring and modeling for Kazakhstan

The existing observation network of the National Hydrometeorological Service for atmospheric air pollution focuses on obtaining information in populated areas of the country. Monitoring research is carried out using provisions two volumes: the Guidebook on Atmospheric Pollution Control (RD 52.04.186-89), and Nature protection. Atmosphere. Rules of control of air quality in the populated areas (GOST 17.2.3.01-86), both adopted during the Soviet period.

To carry out background monitoring in Kazakhstan, only one station, Borovoe, was set up (in North-Kazakhstan Oblast). Methodological guidance was delegated to the Institute of the Global Climate and Environment (Russia), responsible for the collection, processing and analysis of observational data.

Accession of independent Kazakhstan to international conventions, and in particular the Convention on Long-range Transboundary Air Pollution, necessitates the development of national environmental monitoring systems that meet the requirements of these conventions.

To undertake the goals and tasks of the EMEP monitoring program for assessment of transboundary air pollution under the CLRTAP, an initial stage of work to develop the monitoring system in Kazakhstan is recommended:

1. Recommence the activities of the Working Group under the Ministry of Environmental Protection of the Republic of Kazakhstan on the development of proposals for accession to the Convention's Protocols, giving priority to the EMEP Protocol. The Working Group should give to due consideration to economic justifications in its proposals.
2. Prepare a feasibility study for the modernization and technical upgrading of the Borovoe background monitoring station, in order to fully carry out tasks under the EMEP monitoring program.
3. Organize programs to introduce and adapt EMEP recommended methodologies and methods of sampling, chemical analysis, and data processing; complete verification of the recommended methods. To carry out these works, a Russian translation of the EMEP Manual for sampling and chemical analysis is required.
4. Develop proposals for developing the legal basis, funding, and equipment for EMEP monitoring program elements in Kazakhstan.
5. A comprehensive approach should be used in the development of EMEP monitoring program elements, based on the development of both national monitoring systems and of interrelationships between modeling and monitoring for assessment and forecasting. This approach would:
   - optimize the number of monitoring stations on the territory of the country;
   - verify modeling data;
   - evaluate the contribution of transboundary pollution; and
   - estimate long-term trends.
6. In the process of working on the elements accepted under the EMEP monitoring program, fully use the support provided by the EMEP centers, in particular in the following areas:

- methods, methodological coverage and technical documentation of work on the elements for the air pollution monitoring program in Kazakhstan;
- training for Kazakhstan experts through international courses and workshops and also through international programs and projects;
- development of national models for pollutant transportation;
- selection of monitoring stations to verify model calculations.

In organizing works on the elements accepted under the EMEP monitoring program, the following recommendations should also be considered:

1. EMEP monitoring program elements should be linked to the existing national environmental monitoring system, with special attention given to the methodology of work. Using instruments and methodologies different those recommended ones under EMEP can be justified.
2. Laboratories where sample analyses are made may be equipped with any modern equipment (in terms of country of manufacture) that is certified for use under the EMEP monitoring program. Opportunities for participation in intercalibration programs and the analysis of standard samples provided by EMEP centers should be considered. Comparison of data gathered by the national laboratory should be made at the EMEP Coordination Chemical Centre (CCC). Recommendations for further modernization and technical upgrading of analytical laboratory can be made based on conclusions prepared by EMEP CCC. Such laboratories need not be numerous: one is sufficient, as the work of two or three monitoring stations is envisaged.
3. There are no strict recommendations as to the location of monitoring stations. All necessary elements of the EMEP monitoring program may be performed at the existing background station. The network of monitoring stations may be extended based on experience gained.
4. Considering that background monitoring stations play an important role for identification of integrated pollution levels as compared to general background levels, it is necessary to strengthen the monitoring program at the Borovoe background monitoring station and in the future to extend network of the background monitoring stations.
5. Regarding modeling data, it seems possible to use the national observational network to verify modeling of transboundary pollution. For this, the EMEP program can provide calculation data from the Meteorological Synthesizing Center-West (Oslo) on sulphur, nitrogen, volatile organic compounds, surface ozone; and data of the Meteorological Synthesizing Center-East (Moscow) on heavy metals and POPs. To identify local pollution sources, subregional modeling with a higher degree of detail shall be applied.
6. In model calculations and monitoring, it is necessary to consider that Kazakhstan is a large source of salt and dust transported from the dry bed of the Aral Sea. Joint measurements of soil and air pollution are recommended, possibly to be carried out through an expeditionary program. EMEP may provide assistance for the analysis of such information, as well as in the assessment of processes of salt and dust transport.

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