TOMSK POLYTECHNIC UNIVERSITY

E.G. Yazikov, A.V. Talovskaya, L.V. Nadeina

GEOECOLOGICAL ENVIRONMENTAL MONITORING

Recommended for publishing as a study aid
by the Editorial Board of Tomsk Polytechnic University

Tomsk Polytechnic University Publishing House
2013

UDC 55:504.064 (075.8)
BBC 26.3:20.1я73
Y33

Yazikov E.G.

Y33 Geoecological environmental monitoring: coursebook / E.G. Yazikov, A.V. Talovskaya, L.V. Nadeina; Tomsk Polytechnic University. − Tomsk: TPU Publishing House, 2013. – 131 p.

The coursebook presents materials on modern environmental monitoring. Classifications of monitoring, definitions and programs are under consideration. Methods and principles of monitoring organization are given. Monitoring of certain natural environments is discussed on the basis of different instructive materials, methodical recommendations and standards. Brief description of investigation and analytical methods for monitoring organization are also introduced.

The coursebook is intended for students and masters of ecological specialties, but could be quite useful for lecturers, students and experts who call themselves "environmentalists" and are interested in speaking on the problems of ecology, geoecology and environment.

UDC 55:504.064 (075.8)
BBC 26.3:20.1я73

Reviewers

Candidate of Geological and Mineralogical Sciences
Junior Researcher

E.E. Lyapina

Candidate of Philological Sciences,
Associate Professor

I.A. Matveenko

TABLE OF CONTENTS

INTRODUCTION

The manual development is dictated by need to generalize the environmental monitoring research and to solve theoretical problems and problems of practical importance subject to modern realities.

It was so important to develop this manual because monitoring is the mandatory condition of licensing relationships in the course of business in recent years. Methods and problem solving are mixed and they require serious methodological approaches. So, graduates should be well informed and be ready to use this information in practical activity.

The ecological monitoring aim is to identify ecological risks and to supply infotainment of preparing and management decisions making connected with nature and human healthy protection.

The manual is based on the laboratory course and series of lectures given by the authors on “Geoecological monitoring” (for students (specialization 013600 “Geoecology”, Geoecology and Geochemistry department, TPU). In addition, the literature review and the results of many years authors’ investigations and also the investigations carried out by the team of researchers at the Geoecology and Geochemistry department (the investigations deal with geochemical assessment of urban lands of the South of West Siberia) are widely presented in the manual.

The aim of teaching is to form master basic knowledge to study seriously modern ideas about base concepts and monitoring general structure, to acquire skills of organization and monitoring of some natural environments in the process of territory developing.

Ecological monitoring subject matter is a multicomponent combination of natural objects, structures and phenomena presenting undergone natural and anthropogenic changes complex system.

The manual consists of three Units. Goals and objectives of environmental monitoring, classification, systems and services of monitoring are considered in **Unit 1**. Data of automated system of radiation situation monitoring located in Tomsk oblast’ are cited.

The structure of environmental monitoring and the procedure of monitoring carrying out are presented in **Unit 2**. Methods and types of investigations, observation networks, analytical methods and maps needed to carry out monitoring are considered in some detail in Unit 2. Natural and geological environment assessment criteria are based on sanitary measurements and ecological criteria; and assessments of anthropogenic change level are also taken account.

There is a technique of atmospheric air monitoring, snow cover pollution monitoring, soil monitoring, surface water monitoring and bottom deposit monitoring in **Unit 3**. The description of anthropogenic and mineral formation in dust aerosols and soils examined by authors is presented in Unit 3 and in the process of monitoring it allows identify the scale of contamination and the impact sources. The specificity of dust aerosols and soil material composition on the different plant location areas on the territory of the South of West Siberia is presented in Unit 3.

The authors pursue the aim not only to develop the manual but also to represent the basic materials which are required in the process of geoecological monitoring. Certainly, it is impossible to represent whole material that's why the literature presented in the reference list is expected to be studied. The authors will be grateful to readers for reviews, criticisms and helpful advice, which will be able to remove disadvantages presenting in the manual and to make improvements to its content in future.

1. CONCEPTUAL BASIS OF ENVIRONMENTAL MONITORING SYSTEM

1.1. Principal concept of environmental monitoring

The term “monitoring“ introduced into scientific use comes from English-language literature, from English word monitoring, it means control observation. The word monitoring in turn comes from English word monitor and also from Latin “monitor”, it means “observing”, “warning”. In accordance with standard ISO 4225-80 monitoring is multiple determinations to see some kind of parameter change in some time span.

Environmental Impact Assessment (EIA) is defined by Munn (1979) as the need to identify and predict the impact on the environment and man’s health and well-being of legislative proposals, policies, programs, projects, and operational procedures, and to interpret and communicate information about the impact (Glasson et al., 2005). Glasson et al. (2005) have defined the purpose of EIA as an aid to decision making, an aid to the formulation of the development actions, and an instrument to sustainable development. In order to achieve these goals, EIA requires monitoring data that can be used to identify and predict impacts, and also to evaluate the impacts of a given project once approved. Whereas EIA has been traditionally restricted to projects that are deemed to have significant in pacts on the environment, it has recently expanded to include strategic environmental assessment (SEA) and sustainability assessment (SA).

Monitoring involves the measuring and recording of physical, social and economic variables associated with development impacts. The activities seek to provide information on the characteristics and functioning of variables in time and space, and in particular in the occurrence and magnitude of impacts (Glasson et al., 2005). It offers the possibility of determining or assessing the extend of human impacts on the environment and also compares human impacts with natural variation in the environment. The advantages of monitoring following project implementations are that it can improve project management, it can be used as an early warning system to identify harmful trends in a locality before it is too late to take remedial action, it can help to identify and correct for unanticipated impacts, and it can also be used to provide acceptable data base, which can be used in mediation between interested parties (Glasson et al., 2005).

For the fist time the environmental monitoring concept was formulated by Canadian researcher R. Munn at U.N.O. Stockholm environment protection conference in 1972 (Munn, 1973).

Environmental monitoring has been defined as the observation and study of the environment. This entails objective observations that produce sound data, which in turn produce valuable information that is useful, e.g., in the protection of public water supplies, hazardous, non-hazardous and radioactive waste management, weather forecasting, and global change studies (Artiola et al., 2004).

Monitoring has been defined by James et al. (2003) as observing, detecting, or recording the operation of a system; watching closely for purposes of control; surveillance; keeping track of; checking continually; detecting change. They state that since monitoring implies change, and change implies time, monitoring then means measuring those things that change in a system over time and space. It is a process based on surveying and surveillance, but assumes that there is a specific reason for the collection of data (Spellerberg, 2005).

A similar definition is provided by Study of Critical Environmental Problems (1970) who states that monitoring is a systematic observation of parameters related to a specific problem. Designed to provide information on the characteristics of the problem and their changes with time. Surveying entails the collection of quantitative and qualitative data within a specified time frame without having a preconceived idea of what the results would be. Surveillance introduces the concept of time to surveying, leading to the systematic observation of variables and processes, with the aim of producing time series. It is thus a systematic observations of variables and processes for a specific purpose, such as ascertaining whether a given project is being undertaken according to predefined environmental standards (Spellerberg, 2005; Finlayson, 1996).

Izrael and Gerasimov made a great contribution to monitoring studies in Russia. Later these conceptions were broadened by Emelyanov. We can find theory of geological environmental monitoring problem in Epishin, Korolev, Bondarik, Yarg scientific studies.

Izrael (1977, 1984) was the first to pay attention that it is necessary to watch regularly over effects of nature environment man impact. In his opinion, monitoring is the system of observations which allow mark out human activity biosphere (first of all, pollution) changes. He determined the similar system as environmental anthropogenic changes monitoring. The basic aim of system's formation is to prevent negative effects of nature man impact (fig. 1.1.1).

The monitoring system structure consists of four main units: observation, assessment of environmental condition state, biosphere change projection, predictable condition assessment. As you can see monitoring has been defined by Izrael as observing, detecting changes and inferring biosphere condition changes. But it does not include the function of environment quality and human activity management. But the purpose of environmental monitoring is to get information for implementation management actions.

Gerasimov (1975, 1985) states that monitoring is a system of environmental observations and environmental control for the purpose to make the most efficient use of natural resources, to protect nature and to supply the stable performance of different economic purpose geosystem. The subject matter of monitoring investigation is natural phenomena combination subjected to both natural dynamic change and human transformation.

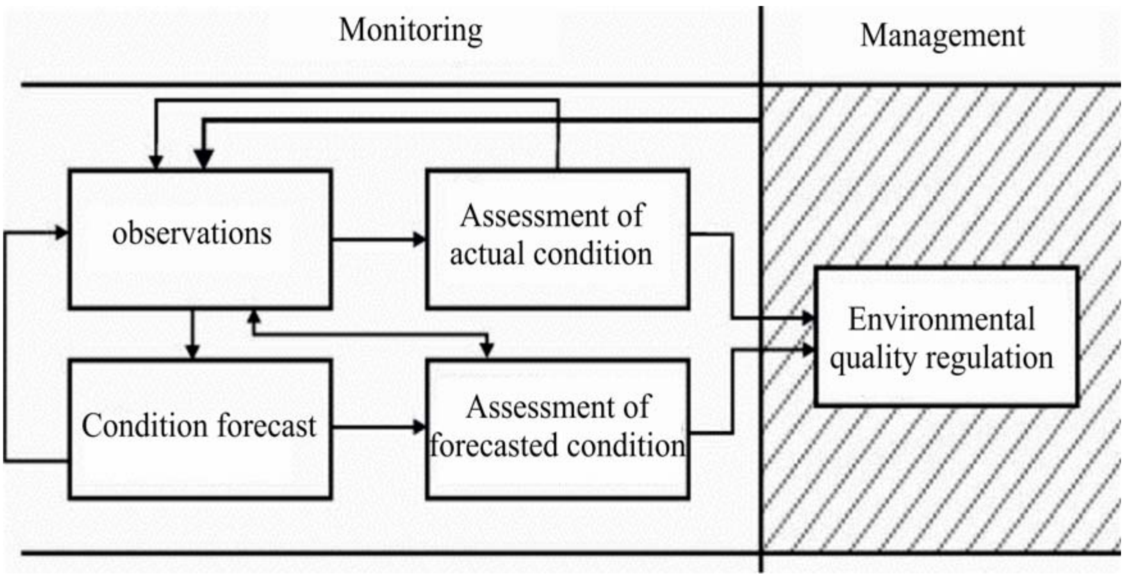


Fig. 1.1.1. Block-scheme of environmental monitoring system (Израэль, 1984)

When monitoring organizing it is necessary to solve some different level goals therefore Gerasimov suggested to distinguish three monitoring stages subject to scale of objects and goals: bioecological (sanitary and hygienic), geosystemic (geoecological – Gerasimov's interpretation) and biospheric (global) (table 1.1.1).

Bioecological monitoring is the receiving of rapid information about environment from a perspective human health environmental effect. Characteristics of surface layers, drinking water, industrial and domestic waste, food and other population health factors are subject to observation and control. *Geosystemic monitoring* is the second stage of observation system. The objects of observations are typical geosystems and ecosystems – natural, natural-anthropogenic (first of all agricultural) and anthropogenic complex (for example, urban territories). *Biospheric monitoring* is the third stage of environmental monitoring. The main task of the third stage is the environmental global parameters observation for the purpose of detecting these changes effects to human health and activity.

Table 1.1.1

System of land environmental monitoring (Герасимов, 1981)

Monitoring stages	Monitoring objects	Specified characteristics of monitoring	Services and locators
bioecological (sanitary and hygienic)	Surface air	Maximum permissible concentration (MPC) of toxic substances	Hydrometeorological, hydroeconomic, sanitary and epidemiological
	Surface and underground waters, industrial waste and sanitary wastewater, various waste	Physical and biological stimuli (noise, allergens and etc.)	
	Radioactive radiations	Maximum level of radiation	
geosystemic (geoecological)	Endangered species of animals and plants	Population condition of species	Hydrometeorological, hydroeconomic, sanitary and epidemiological
	Natural ecosystems	Their structure and abnormalities	
	Agroecosystems	Crop producing	
	Forest ecosystems	Productivity of planting	
biospheric (global)	Atmosphere	Radiation balance, thermal superheating, composition and dusting	International biosphere stations
	Hydrosphere	Rivers and water bodies pollution, water circulation on continents	
	Vegetable and soil cover, animals	Global cycles and balance of CO_2, O_2 and other substances. Global characterristics of soil condition, vegetable cover and animals	

As Gerasimov noted, the monitoring plan suggested him is determined by efficiency of working observation services (hydrometereological, sanitation service etc.). It is very necessary to have clear task and function formulations, activity coordination of information collection and processing.

It is noted in Emelyanov's methodological approach (1994) that the basic aim of monitoring is to prevent negative effects of human economic activity. It is possible when complex geoecological monitoring is based on interaction between anthropogenic effect natural components and their transformation (fig. 1.1.2). The complex monitoring allows get many-sided environmental information, shows up geosystems and ecosystems degradation process and then gives outlook of their future state of environmental condition. However, such kind of monitoring is unrealizable in full and so we are faced with scientific-organizational and methodological work.

According to Emelyanov's conception environmental monitoring system includes three main kinds of activity: observation and control – 1) systematic environmental observation; 2) infer changes – identification of possible nature changes under natural and anthropogenic effect; 3) management actions – environmental regulation activities.

Complex geoecological monitoring includes a wide range of observation objects and connects with a lot of science disciplines (ecology, geology, geography, biology, informatics etc). It allows getting complete nature environment information and using it for management purposes.

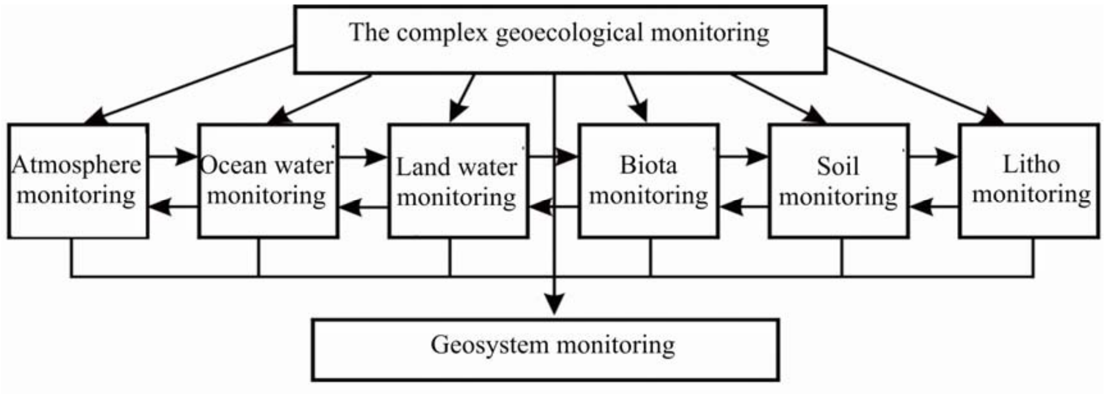


Fig. 1.1.2. Structure scheme of complex geoecological monitoring (Емельянов, 1994)

The definition is provided by Federal Law of Russian Federation "Environmental protection" (ФЗ «Об охране окружающей среды») who states that *environmental monitoring (ecological monitoring)* is a complex system of environment observation, assessment and inferring the changes of environment conditions under the influence of natural and anthropogenic factors.

The thing is monitoring as such does not include functions of environment quality management, first of all it is an information source which requires managerial decision and expertise.

Monitoring objects – environment components – the earth, interior of the earth, soils, surface and underground waters, atmospheric air, flora, fauna and other organisms, and also atmosphere ozone layer and near- Earth space environment, which taken together supply favorable condition of life on the earth.

Summarizing all points of view *complex geoecological monitoring* has been defined as systematical observation connected with natural components and complex anthropogenic changes; this kind of monitoring aims at following assessment, inference and also implementation management actions. In most studies geoecological monitoring is understood as biosphere changes observation and control; as negative effects for human health, life and production activity warning.

There is such concept as *environmental ecologo-geochemical monitoring*. It is organization of environmental components observation system for the real pollution level assessment and for the harmful human healthy situations warning.

First extensive methodological and applied geochemical investigations of urban territories in Russia were started by Yu. E. Saet in 1976 (Методические рекомендации …, 1982; Геохимия …, 1990). These investigations were based, on the one hand, on F.P. Vinogradov, V.V. Kovalskyi, V.A. Kovda and their successors' studies, and, on other hand, they are based on the experience of search geochemistry. Then they were used to give the geochemical estimation of environmental (Методические …, 1982) and surface waters (Методические …, 1985) pollution sources. Similar technical approach was used to investigate ore deposits and to carry out exploration work and to give the estimate of mine environmental effect (Методические …, 1986). Next years scientists of institute of mineralogy, geochemistry and crystal chemistry of rare elements, All-USSR research institute of hydrogeology and geological engineering, All-USSR geological institute, All-Russian institute of mineral raw materials and many other research institutes made a great contribution to upgrading of ecologo-geochemical research and geoecological mapping methodology. Ecologo-geochemical investigations were put on a wide scale in Russia and abroad.

From the beginning of last ten years of XX century the nature conservation and resources problem solving is included in international geochemical mapping project; they are: IGCP–259 – "International geochemical mapping"; IGCP–360 – "Global changes"; «Nord Collot» and «Midle Norden» projects Sweden, Finland, Norway; 17 European countries (A.G. Darnley, J.A. Plant, R. Salminen, A.J. Bjorklund, B. Bolviken, N. Gustavsson, E.K. Burenkov, P.V. Koval, Xie Xuejing at al.).

Ecologo-geochemical technology includes three stages:

1. Initial stage – reconnaissance investigations of geochemical characteristics of environment (reconnaissance – geochemical works).

2. Middle (basic) stage – anthropogenic diffusion halation sorting out and contouring on the ground (geochemical mapping).

3. Completion stage – detailed geochemical and biogeochemical investigations of anomalies.

Everlasting research of the geoecology and geochemistry department team of researchers allow to plan main principles of geochemical monitoring, where efficient complex of chemical-analytical methods and the method of approaching to choice of the most informative nature environments (table 1.1.2) were suggested (Рихванов et al., 1994; Язиков, 2001; 2006):

1. The investigations should be carried out fully and be based on using of geochemical (atmogeochemical (snowgeochemical), lithogeochemical, hydrogeochemical, hudrolithogeochemical, biogeochemical) and geophysical (gamma-radiometric, gamma-spectrometric) methods.

2. The assessment of chemical components accumulation in different parts of territory should be done synchronously (time approximating). Meanwhile the testing of different nature environment components (snow, soil, biota etc) should be sampled in maximal space approximated spots.

3. A lot of nature environment deposit components been able to keep contaminant for a long period of time should be involved in investigation. And as for time intervals accumulation of contaminant they can be established in these components (snow, soil, peat, hair length etc.).

4. Sampling, sample preparation and analysis should be carried out by standardizated methodology using highly sensitive methods of analysis, standard samples and in the certified laboratories. Microbiological water composition and maximal possible complex of chemical components (heavy metals, radioactive and rare earth elements, induced radionuclides and main aromatic hydrocarbons) and etc should be identified.

5. Mineral composition of solid-phase formation in nature environments should be studied simultaneously with general composition using modern methods of investigation (electron microscope, microlog, laser microanalysis, X-ray diffractometry, differential-thermal and other analyses).

6. Geochemical (Th/U, La/Yb, La/Ce, La+Ce/Yb+Lu etc.) and bioindicated characteristics should be used to assess ecological situation in radiation effect areas.

7. Mathematical treatment of geochemical information should be carried out with modern statistical tools (statistical parameters, Fisher's, Rodionov's, Kolmogorov-Smirnov's, Pirson's, Spirman's criteria) paying a great attention to obtained data validity on basis of irregular system of sampling and low sample size.

8. Cartographical connection of points should be carried out in the unified coordinate system and mapping should be done using GIS-technologies.

Table 1.1.2

Principle concept of environment ecologo-geochemical assessment (Rikhvanov et al., 1994; Yazikov, 2001; 2006)

	Study aim	Compounds	Materials for analysis
Snow	Assessment of heavy metals air pollution level	Dust burden, least of 23 elements content in line with State Standard, U, induced radionuclides and other harmful substances (benzo(a)pyrene, pesticides etc.) content	Map of dust load value distribution; Maps of heavy metals distribution; Map of total pollution factor distribution
Soil	Assessment of heavy metals soil pollution level over a long period of time	Identification of total radioactivity, least of 23 elements content in line with State Standard, U, Th, induced radionuclides and other harmful substances (benzo(a)pyrene, pesticides etc.) content	Maps of heavy metals and radioactive elements distribution; Map of total pollution factor distribution; Ecological soil standard of region is worked out
Biota	Assessment of heavy metals biomass pollution level over a long period of time	Least of 23 elements content in line with State Standard, U, Th, induced radionuclides and other harmful compounds content	Maps of heavy metals and radioactive elements distribution; Map of total pollution factor distribution
Water	Assessment of heavy metals water pollution level at this moment of time	Least of 23 elements content in line with State Standard, U, Th, induced radionuclides and other harmful compounds content	Maps of heavy metals and radioactive elements distribution; Map of total pollution factor distribution; Ecological water standard of region is worked out
Atmosphere	Assessment of air pollution level at the moment of measuring	Dust, sulphur dioxide, carbone monoxide, nitrogen dioxide, nitric oxide, ammonia, hydrogen sulfide, chlorine and other harmful substances if necessary	Air pollution maps
Bottom sediment	Assessment of heavy metals bottom sediment pollution level over a long period of time	Identification of total radioactivity, least of 23 elements content in line with State Standard, U, Th, induced radionuclides and other harmful compounds (benzo(a)pyrene, pesticides etc.) content	Maps of heavy metals and radioactive elements distribution; Map of total pollution factor distribution
Scale	Assessment of heavy metals scale pollution level over a long period of time	Identification of total radioactivity, least of 23 elements content in line with State Standard, U, Th, induced radionuclides and other harmful compounds (benzo(a)pyrene, pesticides etc.) content	Maps of heavy metals and radioactive elements distribution; Map of total pollution factor distribution

The term *lithomonitoring* was introduced in 1980 s. It differs from environmental monitoring because it is characterized by narrow notion, studying only lithosphere as the object. *Lithomonitoring* has been defined as regular observation, assessment and projection of anthropogenic and natural geological changes. The main lithomonitoring objects are different geologo-geomorphological processes appeared in upper layers of Earth's crust. Their condition following is carried out with a help of surface, monitoring observations in combination with distant methods use. Ground-based observations are carried out in stationary conditions at the exogenous and endogenous processes (landslides, falling, mud flow, avalanche, piping, tectonic motion etc.) areas.

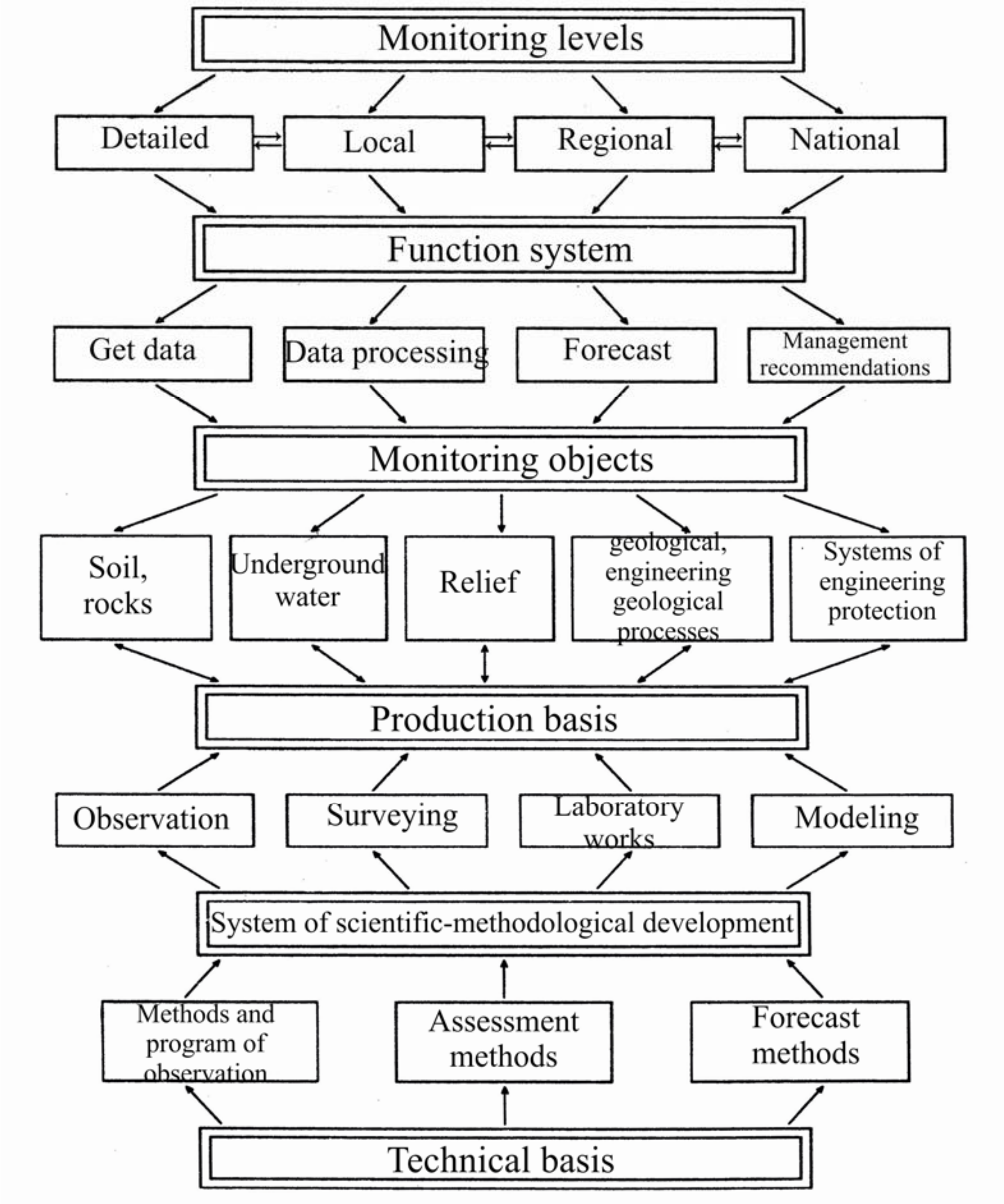


Fig. 1.1.3. General structure of geological environment monitoring (Королев, 1995)

The notions “geological environment monitoring” and “engineering-geological monitoring” appeared simultaneously with the notion “lithomonitoring“. *Geological environment monitoring* has been defined by. Korolev et al. (1995) as observations, assessment, projection and geological environment management system, carrying out in line with prescheduled program and it aims to supply optimal ecological conditions for people within natural-technical system in (fig. 1.1.3).

The system of purposeful engineering-geological, hydrogeological and other geological and ecological activity consisting of ordered procedure set forming cycles: ecologo-geological observations, system assessment, ecologo-geological projection of system development and management is the monitoring main point and content. Then ecologo-geological observations are supplemented with new facts on the new cycle and further cycles are repeated at new period of time.

1.2. Environmental monitoring kind classification

There are a lot of categories of environmental monitoring. They are distinguished by nature of environmental pollution, solved problems, organization levels, observed nature environments, methods and goals observation. However the universally recognized classification is not done.

Environment monitoring has following hierarchy:

- *Global* – regular planetary process and biosphere phenomena tracking.
- *National* – environment tracking in one country (e.g., Russian state monitoring system).
- *Regional* – in administrative region or nature regions (for example, oblasts or large river and lake basins), region and oblast system environmental monitoring.
- *Local* – tracking is carrying out on the small areas (towns, small river basins, morphological parts of landscape and etc.).
- *Detailed* – is carrying out at the deposits, plants, economic complex and etc., i.e. it is *production ecological monitoring* which is carrying out at the plant territory; the aim of this monitoring is to supply ecological safety, to obtain reliable environmental information, to supply fulfillment environmental protection legislative requirements and normative standards (fig 1.2.1).

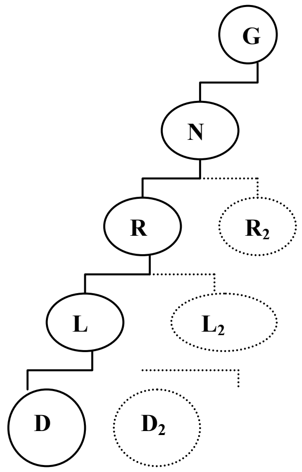
Levels of monitoring	Structural diagram	Belonging
Global		Intergovernmental system of International Organization for Standardization (IOS)
National		State monitoring system of Russia's territory
Regional		Krai and oblast' systems of International Organization for Standardization (IOS)
Local		Town and district systems of International Organization for Standardization (IOS)
Detailed		Fields, plant facilities, economic complexes, etc.

Fig. 1.2.1. Structural diagram and relation of environmental monitoring systems of different levels (Королев, 1995)

Spellerberg (2005) provides examples of cases where people have categorized monitoring. On one example, Spellerberg (2005) cites the Department of Conservation in New Zealand who recognizes three types of monitoring (results monitoring), outcome monitoring and surveillance monitoring. In another example, Spellerberg (2005) provides four categories of environmental monitoring based on (Vaughan et al., 2001):

Simple monitoring, records the value of a single variable at one point over time.

- *Survey monitoring*, surveys the current state of environmental conditions in both affected and non-affected areas.
- *Surrogate or proxy monitorin*g, which compensates for the lack of previous monitoring by using surrogate information to infer changes.
- *Integrated monitoring*, using detailed sets of ecological information.

Downes et al. (2002) on the other hand classify monitoring into four categories that clarify the objectives of monitoring prior to a specific design. These are as follows:

Environmental monitoring. This takes on many forms for many objectives, e.g., those undertaking environmental monitoring might be interested in gaining some indication of the state, as opposed to assessing human impacts upon the environment, of a particular place.

Long term monitoring and reference site monitoring. These are forms of environmental state monitoring that are useful in providing a background measure for the long term dynamics of natural systems that may be used to indicate systematic, monatomic, or cyclical changes in the environment at large scales over long time periods. They are relevant in providing frame-works upon which shorter term or localized changes such as those arising from anthropogenic impacts could be measured against.

Compliance monitoring. This seeks to ensure that a stipulated regulation is being followed, e.g., measuring the pollution level of effluent at a given location without bothering with neighboring locations outside of the area of interest. The objective in compliance monitoring is usually to assess whether the level of particular compounds are below critical levels stipulated under some regulatory framework. Compliance monitoring could be also viewed as quality control measures.

Impact monitoring. This is undertaken to assess the human impact upon the natural environment, with the objective of taking remedial measures to prevent or minimize such impacts. This type of monitoring is useful in compliance and impact assessment monitoring.

With increasing development and technological advancement in the world, the task of monitoring the environment continues to become more important, as noted, e.g., by Burden et al. (2002), who elucidates the role and practice of environmental monitoring. Burden et al. (2002), in realizing the importance that underpins environmental monitoring of water, soil and sediments, and the atmosphere. Their work also considers chemical, physical and biological monitoring, all aimed at enhancing environmental management.

Khutorcki et al. (1999) classify monitoring into six categories. These are as follows:

1. Classification in line with component biosphere reaction observation : biological (biotic); geophysical (abiotic);

2. Classification in line with factors and objects effect monitoring. Classification in line with effect factors includes monitoring of different chemical pollutants (ingredient monitoring) and various natural and physical effect factors (electromagnetic radiation, noise vibration). According to object observation the atmosphere, air, water, soil, climate monitoring and also the flora, fauna, human healthy monitoring are distinguished.

3. Systems and subsystems classification (Yu. A. Izrael's monitoring) a) certain natural components monitoring b) geosystem (landscape-ecological) monitoring – natural and natural-anthropogenic geosystem and ecosystem tracking.

4. Classification in line with observation methods: satellite (distant), chemical, physical, biological.

5. Classification in line with degrees of impact: global, national, regional, local, impact.

6. In line with character of information fusion there are following monitoring systems: global, base (background), national, regional, local, impact.

Table 1.2.1

Classification of monitoring systems (subsystems) (Экология ..., 2000)

Principle of classification	Existing and designed monitoring systems (subsystems)
Universal systems	Global monitoring (base, regional, impact levels), including baseline monitoring and paleomonitoring. National monitoring (such as: Federal monitoring service of environmental level of pollution). International monitoring (such as: Monitoring of transboundary pollutants transport)
Reaction of biosphere fundamental components	Geophysical monitoring. Biological monitoring, including genetic monitoring. Ecological monitoring (including above-named ones)
Different environments	Monitoring of man-made changes (including pollution and pollutant response) in atmosphere, hydrosphere, soil, cryosphere and biota
Factors and sources of impact	Monitoring of pollution sources. Ingredient monitoring (for example, certain pollutants, radioactive radiation, noise, etc.).
Acuity and globality of problem	Ocean monitoring. Ozonosphere monitoring
Observation methods	Physical, chemical and biological parameters monitoring. Satellite monitoring (remote sensing methods)
Systemic approach	Medicobiological monitoring. Ecological monitoring. Climatic monitoring. Variants: bioecological, geoecological, biospheric monitoring

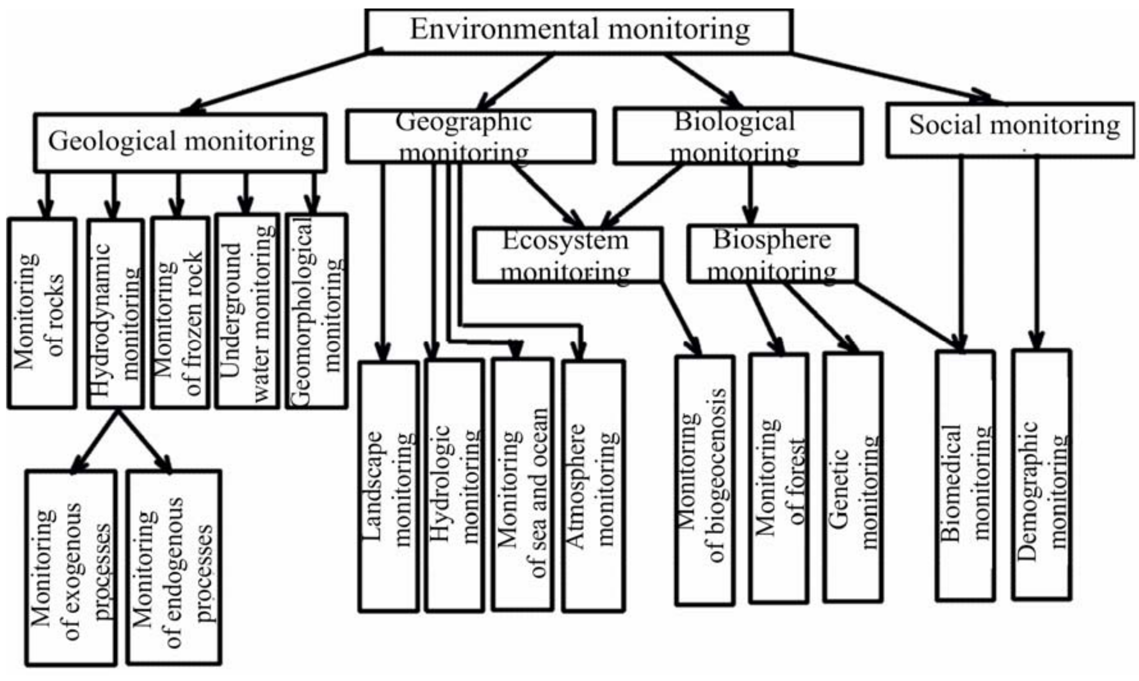


Fig. 1.2.1. Structural system and relation of system of the different levels environmental monitoring (Королев, 1995)

According to objects under observation there are atmospheric, water, soil, climatic monitoring, flora and fauna monitoring, and population health monitoring. There is also the monitoring classification connected with facts, sources and degrees of impact (table 1.2.1).

Nature environment observation should be included effect sources observation: point stationary sources monitoring (chimney stalks), point mobility sources (transport), spatial sources (cities, fields with carried into chemical substances) (Экология …., 2000).

There are such types of monitoring as geological monitoring, geographic monitoring, biological and social monitoring (fig 1.2.1).

1.3. Environmental monitoring systems and services

1.3.1. Global environmental monitoring system

Global environmental monitoring system (GEMS) was founded by joint efforts of world community (program fundamentals and goals were formulated in 1974 at the first intergovernmental meeting dealing with monitoring) according to UNO conference results, this conference held in Stockholm in 1972 as it was said before. The coordination centre is situated in Nairobi (Kenya).

Global environmental monitoring is a regular biosphere global processes tracking for the purpose of assessment and prediction changes under anthropogenic and natural factors. Goals: main parameters observation and control: geophysical, geochemical and biological characteristics; thermal and radiation balance; hydrological cycle; ozone layer; radioactivity level.

Monitoring system is realized in some levels which are line with special programs (before mentioned in monitoring classification unit: impact (I), regional (R), background (on the nature reserve territory where any economic activity is taken away (B). It is realized through the international program "Man and biosphere".

The stations represent the GEMS network of Regional and Contributing (background) stations which add significantly to the global observing systems.

Contributing stations are intended to obtain biosphere background (baseline) information and that is why they should be situated in districts where there is no anthropogenic effect. It is necessary to place them at special chosen points: both on the land and sea water of the Great ocean. In Russia organized *contributing* stations are functioned essentially as part of the biosphere nature reserves. *Regional stations* are organized to obtain biosphere information in the human economical activity impacted areas. They can be situated near cities and industrial centers.

The observation programs are formed on the principle of priority (being determined first) contaminant and integral (reproducing the group of phenomena, processes and substances) characteristics choice. The classes of priority ranking of contaminant established experimentally and adopted in GEMS are showed in table 1.3.1.1.

Table 1.3.1.1

Priority contaminant classification and contaminant content control in different environments (Экология ..., 2000)

Class of priority ranking	Contaminant	Environment	Measurement program type
I	Sulfur dioxide and suspended particles Radionuclide (Sr-90, Cs-137)	Air Food	I, R, C, G I, R
II	Ozone Dichlorodiphenyltrichloroethane (DDT) and other chlorine organic compounds	Air, biota, human	I, C I, R
III	Nitrate, nitrite Nitric oxide	Drinking water, food Air	I I
IV	Mercury and its compounds Lead Carbon dioxide	Food, air Air, food Air	I, R I B
V	Carbon monoxide Oilhydrocarbones	Air Sea water	I R, B
VI	Fluoride	Drinking water	I
VII	Asbestos Arsenic	Air Drinking water	I I
VIII	Microtoxin Microbiological contamination Reactive hydrocarbon	Food Food Air	I, R I, R I

Note: I – impact, R – regional, C – contributing (base), G – global.

As for observation environments atmospheric air and fresh water bodies deserve first-priority attention. The priority ranking of components is determined in consideration of criteria indicating contaminant toxic properties, quantity of them in environment, characteristics of their transformation, frequency and human and biota impact value and other factors.

Environmental global changes information can be also obtained with a help of satellites. **Program EOS** (Earth Observing System) is intended for implementation of the Earth investigation NASA strategic project published in 2001. It is included in Mission to Planet Earth (MTPE) project, carried out by NASA since 1991 according to program “Investigations of the Earth global changes". According to program EOS for 15 years it is planned to study the planet as the uniform integrated system from all sides.

The World Meteorological Organization (WMO) is a specialized agency of the United Nations. It is the UN system's authoritative voice on the state and behavior of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.

WMO has a membership of 189 Member States and Territories (on 4 December 2009). It originated from the International Meteorological Organization (IMO), which was founded in 1873. Established in 1950, WMO became the specialized agency of the United Nations in 1951 for meteorology (weather and climate), operational hydrology and related geophysical sciences.

WMO promotes cooperation in the establishment of networks for making meteorological, climatological, hydrological and geophysical observations, as well as the exchange, processing and standardization of related data, and assists technology transfer, training and research. It also fosters collaboration between the National Meteorological and Hydrological Services of its Members and furthers the application of meteorology to public weather services, agriculture, aviation, shipping, the environment, water issues and the mitigation of the impacts of natural disasters.

WMO Members have long recognized the importance of atmospheric chemistry in their weather, climate and air quality programmes and activities. In 1989, this resulted in the establishment of the Global Atmosphere Watch (GAW) Programme by the forty-first session of the WMO Executive Council. In so doing, two long-term monitoring programmes dating back to the 1970s or earlier were merged: the Global Ozone Observing System (GO3OS) and the Background Air Pollution Monitoring Network (BAPMoN) (http://www.wmo.int/pages/index_en.html).

The GAW monitoring system focuses on six classes of variables (i.e. ozone, UV radiation, greenhouse gases, aerosols, selected reactive gases and precipitation chemistry).

A network of measurement stations is the backbone of the GAW programme. This network consists of GAW Global and Regional measurement stations with additional measurements from contributing stations. Both Global and Regional stations are operated by their host countries, either by their National Meteorological Services or by other national scientific organizations. More than 80 countries actively host GAW stations.

Currently GAW coordinates activities and data from **28** Global stations, **410** Regional stations, and **81** Contributing stations operated by Contributing networks (fig. 1.3.1.1).

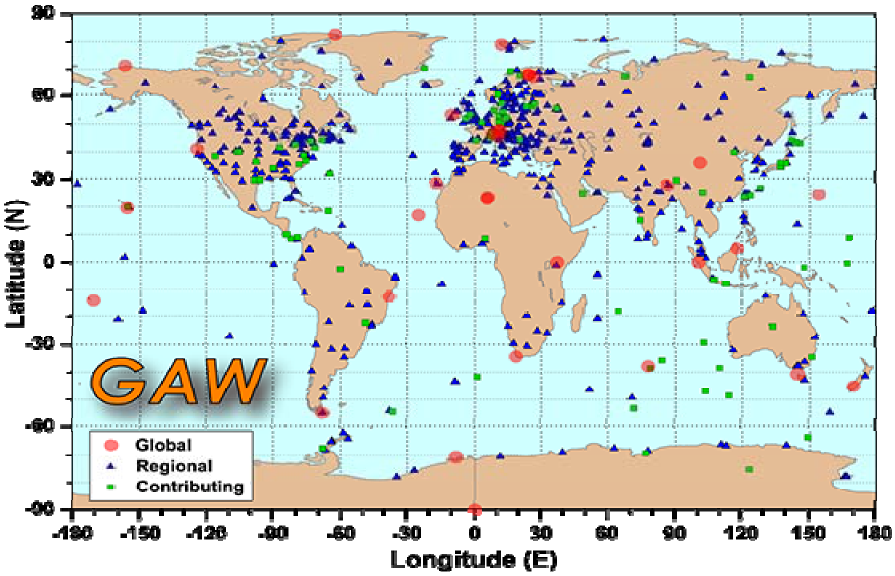


Fig. 1.3.1.1. GAW measurement network

In recent years satellite programmes have produced important measurements of atmospheric compounds and related parameters that complement the GAW network measurements (fig. 1.3.1.2). When highly accurate local measurements from GAW ground-based stations are coupled with the near global coverage of satellite measurements it results in a more complete picture of atmospheric composition and processes on global scales, and provides complimentary checks of instrument calibrations (http://www.wmo.int/pages/prog/arep/gaw/measurements.html).

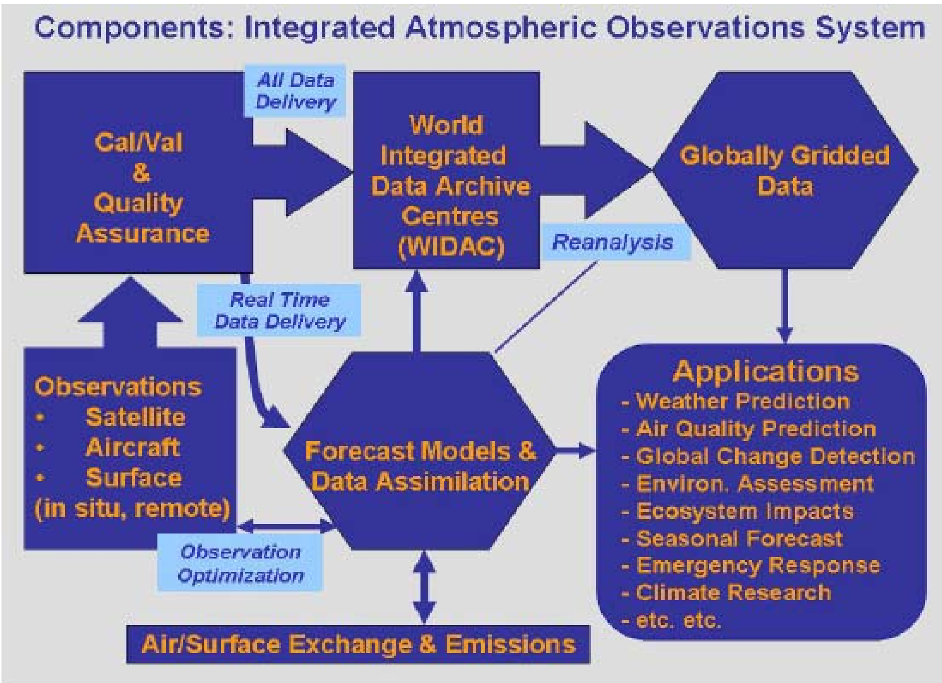


Fig. 1.3.1.2. Framework of a global integrated atmospheric observations system (http://www.wmo.int/pages/prog/arep/gaw/measurements.html)

The World Weather Watch system, an extensive international system for collecting and reporting meteorological data, is coordinated by the World Meteorological Organization. Through this system, weather data are collected by the Global Observing System, distributed by means of the Global Telecommunication System, and processed in the Global Data-Processing System. The WMO, the Intergovernmental Oceanographic Commission, and ICSU in 1991 agreed to begin the Global Climate Observation System (GCOS). GCOS will be based on the integration of existing and planned climate monitoring programs, including WMO's World Weather Watch system (Environmental geology, 1999).

1.3.2. Environmental monitoring system in Russia

In Russia the environmental monitoring was carried out for the first time in 1930s and mainly dealt with surface waters as a source of water supply. The radioactive contamination observations connected with the nuclear weapon test were organized in 1950s on the base of ramified system of Hydrometeoservice. In big cities the air quality observations have been carrying out since 1963 though the uniform *state system of environment pollution observation and monitoring* (SSOM) was formed in 1972. Within 20 years of SSOM work impressive results were obtained. This system laid down the foundation of methodology and which is used in full at present. Sorry to say, by the beginning of 1990s the well-done SSOM was wrecked and transferred to another organizations and departments (Хаустов, Редина, 2008). The uniform state system of ecological monitoring (USSEM) was founded by Council of Ministers – RF Government resolution № 1229 in 1993. It must unite possibilities and efforts of many services to solve environmental complex observation, assessment and projection problems in Russian Federation.

Russian Federation Government resolution from 31.03.2003 № 177 "About organization and carrying out state monitoring of environment (state environmental monitoring)" ("Об организации и осуществлении государственного мониторинга окружающей среды (государственного экологического мониторинга)") helps to take a different view of environmental quality observation systems. *The state monitoring of environment (state environmental monitoring)"* has been defined by this resolution as a complex system of environmental observations and the observations of natural and anthropogenic factors changing assessment and projection. According to National Law (NL) of Russian Federation (RF) "Environmental protection" ("Об охране окружающей природной среды") the organization and carrying out monitoring is supported by RF and constituent territory of the federation legislation.

The uniform state system of ecological monitoring (USSEM) is a constituent part of monitoring global system (fig. 1.3.2.1).

The ecological monitoring includes the atmospheric air, lands, soil, forests, water bodies, fauna monitoring and the unique ecological system of the Baikal, continental shelf of RF, the state of subsurface, exclusive economic area of RF, internal sea waters and territorial sea of RF.

The observational network includes stationary and mobility stations of observation (sites, stations and etc.) meant for physical and chemical processes observations, the meteorological, climatic, aerological, hydrological, oceanlogical characteristics identification and the air, soil, water bodies level definitions.

Environmental component monitoring is carried out at the observational stations which form the state observational network. National service includes base and regional observational stations.

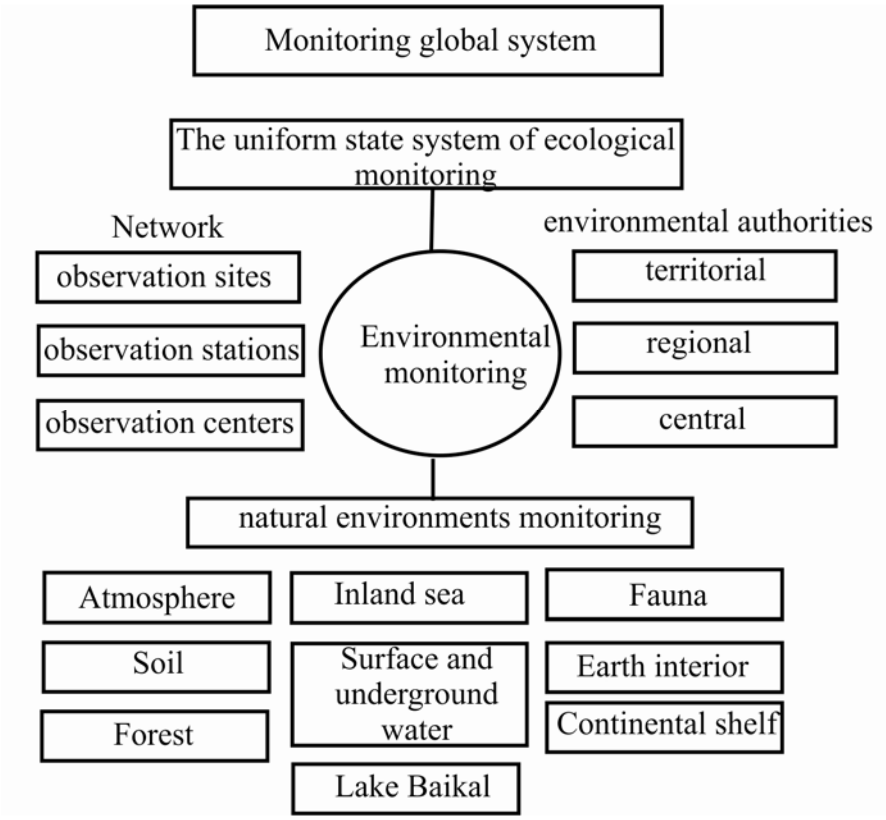


Fig. 1.3.2.1. Integrated national system of Russia ecological monitoring (Лотош, 2007)

The multibranch network of observing and watch stations of Russia Federal service of hydrometeorology and environmental monitoring (Rushydromet) is used widely to keep under observation the pollution of natural environment. Widespread network of air pollution watch stations has been constructed in cities and large settlements.

As a rule, the competent authorities (territorial, regional and central forms of government) share the liability for monitoring carrying out between them.

About 20 ministries and departments (RF National Resources Ministry, Russia Federal service of hydrometeorology and environmental monitoring and etc.) support the organization and carrying out ecological monitoring.

For example, Rushydromet makes observations of radioactive and chemical pollution of air, surface waters and soils. The complex background monitoring is carried out. Rushydromet is also carried out the material preparation and presentation of environment impact assessment on the territory of the country; Rushydromet keeps the sections of United State Fund of Data on the State of the Environment and Environmental Pollution.

At regional level the ecological monitoring is charged with Ecological Committee (operating plants' emission and waste observation and monitoring). The inherent emission and waste observation and monitoring is charged with plant facilities – operational ecological monitoring (Khaustov, Redina, 2008). For example, in Tomsk region the main authority is the environmental protection State Committee, consisting of the natural resources and environmental protection department, oblast' state administration (OSA) "Oblcompriroda". Company limited (Co Ltd) "Tomskgeomonitoring" carries out geological environment observations in Siberia.

Tomsk hydrometeorological and environmental monitoring centre must organize and carry out hydrometeorological processes and environmental pollution observations in Tomsk region.

Industrial ecological monitoring for environmental protection is carried out on the enterprise territory. Its aim is to ensure ecological security, to get reliable information about environment, to provide the execution of demands for environmental protection established by the legislation of the Russian Federation. It includes air protection monitoring; ecological water consumption and water disposal monitoring; waste generation, reclamation of waste materials and waste disposal monitoring; it also includes the use of nature resources and environmental management monitoring (Хаустов, Редина, 2008).

The United state automated system of radiation environment monitoring (USASREM) was organized at Russia territory. USASREM was created for the purpose of Government Resolution of the Russian Federation of 02.10.95 № 1085 for providing the requirements of regulations: "On nuclear energy use", "On radiation safety of population", "On environmental protection", "Concerning the protection of the population and areas against natural and man-made emergencies". USASREM is aimed to provide the public authorities and inhabitants with reliable radiation environment information to assume the well-timed and adequate measures under the conditions of initiation of radiation hazard.

At present the Rushydromet, Minatom of Russia, Ministry of Defense of Russia, Ministry of Public Health and Agriculture Ministry of Russia have got the overdeveloped systems of radiation environment monitoring.

The Rushydromet system of radiation monitoring and lab control carries out observations of soils, atmospheric air, surface water radioactive pollution levels (fig. 1.3.2.2).

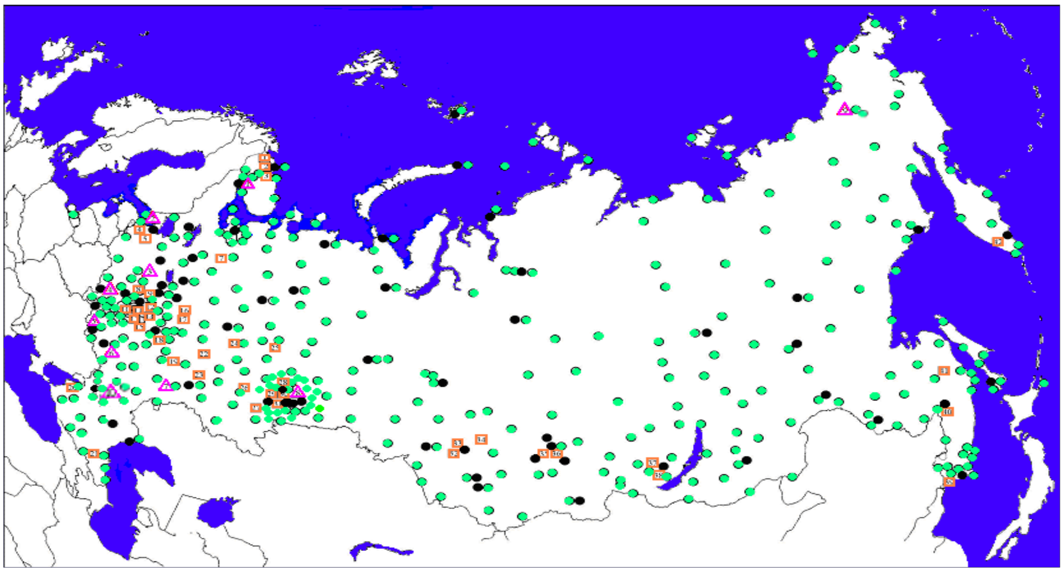


Fig. 1.3.2.2. Monitoring network of environmental radioactive contamination (according to the data from Rushydromet)

Δ – NPS; □ – radiation hazardous sites
● – aerosols
● – fallouts

It includes about 1300 meteostations and points equipped with exposure dose of gamma-ray devices, about 500 sampling sites for total beta-activity measurement and over 150 atmospheric precipitations and water sampling sites. There are about 40 laboratories.

The automated system of radiation environment monitoring (ASREM) is one of the USASREM constituent (fig. 1.3.2.3).

Examine ASREM by way of example Tomsk region. The first phase of ASREM foundation was performed in 1993–1995 after the well-known accident at Siberian Group of Chemical Enterprises (SGCE) in April in 1993.

ASREM goal is to provide the public authorities and inhabitants with reliable radiation environment information in 30 km area of Siberian Group of Chemical Enterprises. State Committee of Ecology and Tomsk hydrometeorological and environmental monitoring centre take the lead in

ASREM in Tomsk region. 25 autonomic stationary exposure dose of gamma-ray stations were founded at territory of region (30 km zone of Siberian Group of Chemical Enterprises) and three centers of initial information accumulation were equipped from 1995 to 1998.

The stations are situated in 9 settlements (Dzerzhinskiy, Zorkoltsevo, Gubino, Moraykovka, Samus', Georgievka, Malinovka, Svetlyi, Naumovka), Tomsk Petrochemical enterprise (TPCE), complex of treatment facilities, Tomsk Petrochemical enterprise (TPCE), educational and research nuclear reactor of TPU; town Seversk (9 stations); Tomsk – 4 stations (river port, Yuzhnaya square, Irkutskiy street, Smirnov street).

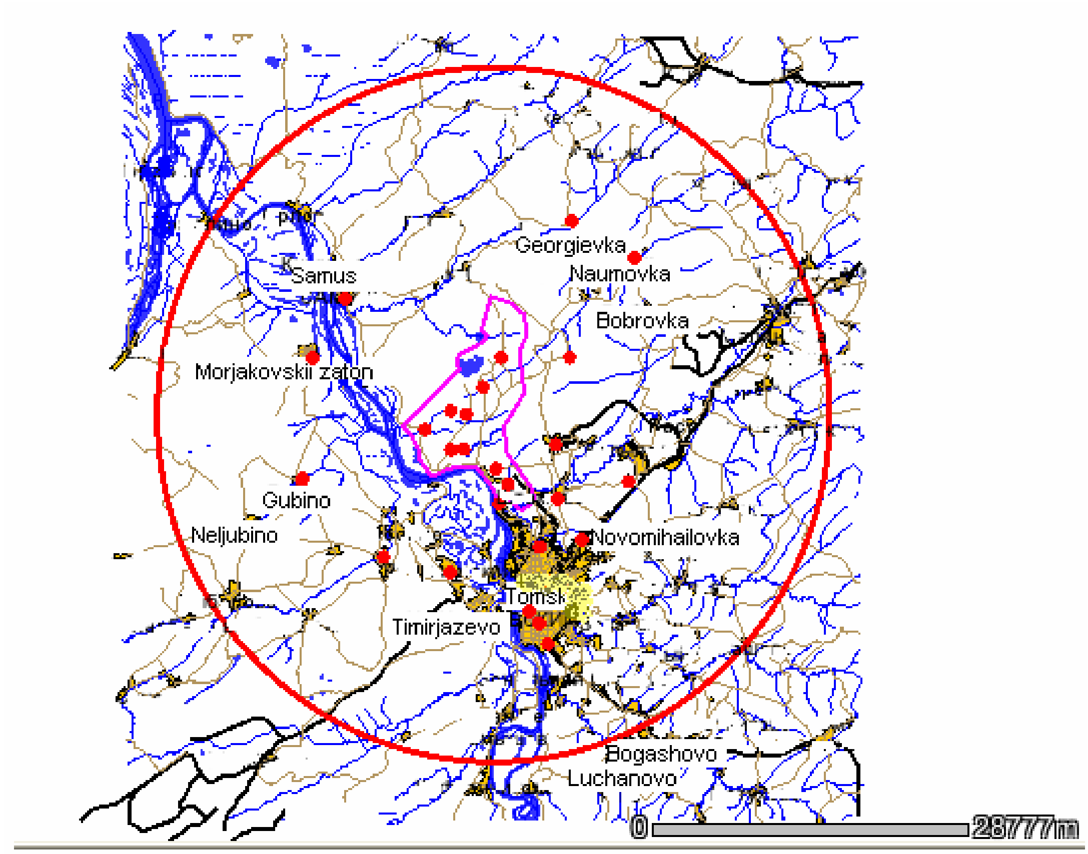


Fig. 1.3.2.3. Scheme of post location the automated system of radiation environment monitoring within a radius of 30 km Siberian Group of Chemical Enterprises (по данным State Committee of Ecology)

Whole information is passed automatically to 3 information gathering centers: in Tomsk hydrometeorological and environmental monitoring centre, in Seversk civil defense and emergency services, in State Committee of Ecology (in radiation monitoring department).

Every station measures exposure dose rate of gamma-ray at stated intervals (one, two, four or eight). It saves measurements in memory and passes them to the center one or some times a day in accordance with the determined program or operator request. If radiation environment becomes worse and exceeds determined value exposure dose of gamma-ray (30 mcR/h) the stations gets connected with the center independently and turn on special signal. This signal can be turned off only when a duty operator takes the readings. In addition the duty operator can inform about failing (detecting sensor), illegal access, cable breakdown in station system.

According to the data analysis carried out by the system ASREM it is possible to take note that the Siberian Chemical Combine (SCC) didn't contribute significantly to forming gamma-background on the territory of Tomsk oblast' (for 2001–2010). The capacity value of exposure dose was 9–11 mR/hr. According to data ASREM within studying period of time the whole levels of exposure dose rate (EDR) vary within natural radiation background typical for Tomsk oblast' and Western Siberia.

Revision

1. Give a definition of the term «environmental monitoring» and enumerate its functions.
2. What does the geoecological monitoring differ from the ecologogeochemical monitoring?
3. Give a definition of the term «geological environment monitoring».
4. What types of monitoring do you know?
5. What are the primary purposes, parameters and members of global environmental monitoring?
6. Characterize goal and structure of Russian state environmental monitoring.
7. Define goals and objectives of industrial ecological monitoring.
8. What is the radioactive contamination environmental monitoring?

Answer the following questions:

1. When, where and by whom was the environmental monitoring introduced for the first time:

a) Yu. A. Izrael', at Stockholm conference U.N.O in 1978;
b) R. Man, at Stockholm conference U.N.O in 1972;
c) N. Smith, at Stockholm conference U.N.O in 1954;
d) Peter Sharden, at Stockholm conference U.N.O in.

2. Subject to objects and tasks what levels of monitoring were marked out by I. P. Gerasimov:

a) geosystemic; b) ecological;
c) biospheric; d) bioecological;
e) sanitarian; f) analytical.

3. Match the stage to the work type in the ecologo-geochemical monitoring:

1) initial stage : a) detailed geochemical and biogeochemical investigations of anomalies;
2) basic stage: b) geochemical mapping;
3) completion: c) reconnaissance – geochemical works.

4. What monitoring levels are there in the monitoring structure chart:

a) global; b) planetary;
c) national; d) race;
e) regional; f) local;
g) detailed; h) impact.

5. What types of monitoring classification are there:

a) dealing with observations of biosphere response;
b) dealing with influencing factors and objects of environmental monitoring;
c) dealing with degree of impact;
d) dealing with observation methods;
e) dealing with systems and subsystems.

6. According to observation methods what types of monitoring are there:

a) chemical; b) analytical;
c) remote; d) biological;
e) physical-chemical; f) physical.

7. Environmental monitoring observation network includes:

a) stationary stations; b) center stations;
c) mobility stations; d) automatically stations.

8. ASREM means:

a) automated system of radiation environment monitoring in Russia;
b) automated system of radiation environment monitoring in Tomsk oblast;
c) global automated system of radiation environment monitoring.

2. METHODS AND ORGANIZATION OF ENVIRONMENTAL MONITORING

2.1. Methods and types of investigations

To function ecological monitoring systems include following stages:

- Identification of the object under observation.
- Examination of the sorted out object under observation.
- Make the observed object information model.
- Measurement planning.
- The object under observation assessment and identification of its information model.
- Prediction of the object under observation change.
- Representation of in an easy-to-use form information and communication it to consumers (Хаустов, Редина, 2008).

Within all these stages, a framework for designing a monitoring program is essential. For instance, Finlayson (1966) presented a framework that consists of the identification of issues or problem, definitions of objectives, formulation of hypothesis, choosing the desired methods and variables to observe, assessment of feasibility and cost effectiveness, conducting pilot studies, collecting samples, analyzing the collected samples, interpreting data and reporting the results, and implementing management actions.

A similar model is presented by Maher and Batley as reported in Burden et al. (2002), who point out that good monitoring programs obtain information and are not just data collection exercise and as such should be cost effective, yet provide information and knowledge to inform those commissioning the data collection.

Five stages of environmental monitoring program implementation are presented in Khaustov, Redina paper (2008) (fig. 2.1.1).

The first stage is data collection. Development, introduction of production ecological monitoring system begin with existing information analysis. The archival and literature facts about the territory are studied. Object of observation information gathering – the main pollution sources, affected area, contaminant types, and analysis of previously made investigations – is carried out.

Initial information composition for production ecological monitoring design depends on the industrial project life-cycle: pre-constructional, constructional, operation stage, liquidation stage.

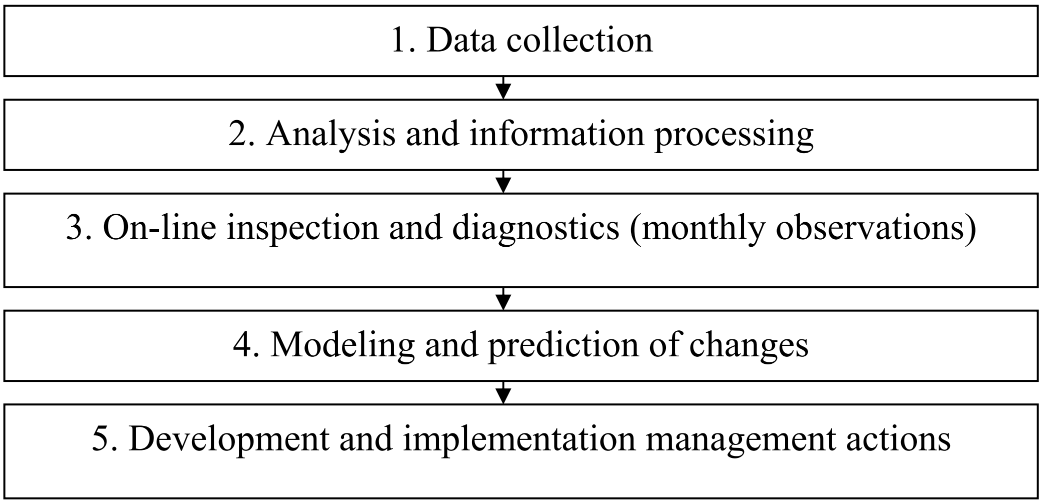


Fig. 2.1.1. Structure of environmental monitoring system (Хаустов, Редина, 2008)

Collection of materials for design includes:

- Data of engineering, including engineering – ecological, prospecting.
- Planed-cartographical materials of object placement region.
- Approved plan of land use.
- General characteristic of object.
- Map (with putting on it pollution sources) of industrial site, manufacture building.
- Materials of economic activity object feasibility study, which received positive conclusion of the examination.
- Data of environmental effect assessment.
- Data of emission, waste, sewage water disposal areas and etc.
- Information about given emission and discharges permission (maximum permissible concentration or temporarily agreed emission, maximum permissible discharges or temporarily agreed discharges), waste formation and placement, water consumption and water disposal.
- Data of factory's passport.
- Data of state statistical reporting by form 2-ТП (air, recultivation, toxic waste and etc.).
- Other necessary information (Хаустов, Редина, 2008).

Collection and systematization of existing information about structure and geological environment condition, geological environment anthropogenic load are carried out. The studied territory's maps are made (fig 2.1.1).

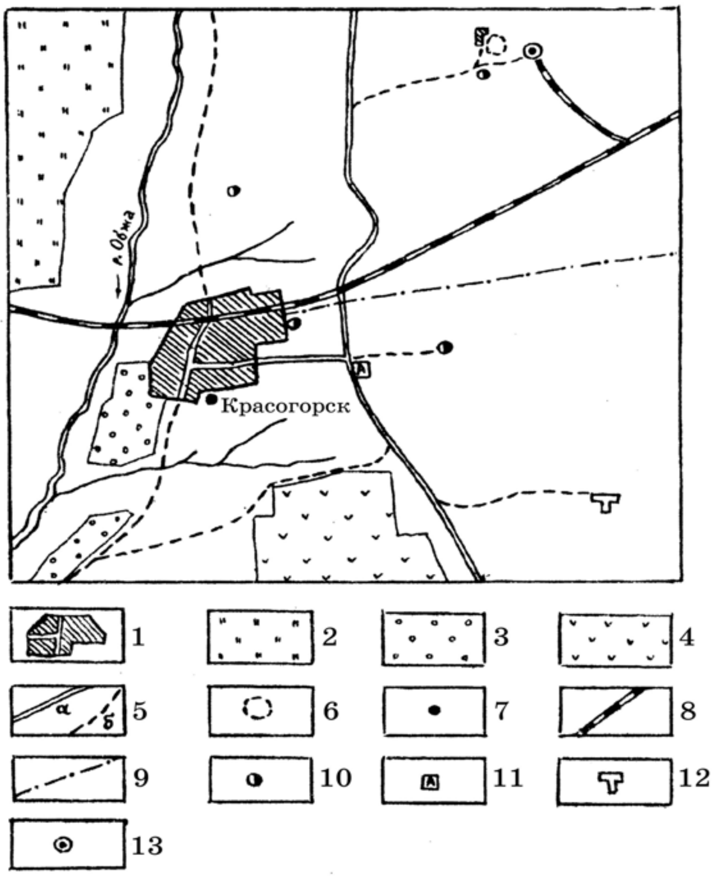


Fig 2.1.1. Schematic map of the territory development (fragment):
1 – settlement; 2 – agricultural land (grain crops); 3 – vegetable gardens (vegetables); 4 – irrigated fields; 5 – roads: highways (a), dirt roads (б); 6 – surface mines; 7 – water intakes; 8 – electrified railway; 9 – power transmission line (PTL); 10 – dumps of solid domestic waste; 11 – gasoline stand; 12 – cattle farms; 13 – cement plant (Королев, 1995)

Interpretation of carried out investigation results consists in:

- decoding of space and aero photos;
- aerogramme- spectrometric survey;
- geochemical investigations;
- hydrogeological;
- engineering – geological;
- hydrogeochemical;
- hydrolithogeochemical.

The decoding of the results of aerospace survey materials allows us divide the studying region into certain natural-territorial complex. The decoding of the results of space and aerophotos allows us show up pollution sources and contaminant spreading areas of studying territory.

Materials of aerogramme-spectrometric survey (AGSS) will allow us obtain information about natural or anthropogenic contamination (natural or artificial origin radioactive elements or radionuclides) of studying territory, show up polluted areas.

The results of geochemical investigations will allow us determine the list of chemical elements which are typical for such kind of manufacture. It will allow carry out the monitoring of specific element concentration level in affected areas of plant facilities.

Hydrogeological and hydrogeochemical investigations will allow us determine regularities of underground water levels, conditions of groundwater recharge and discharge, resources, interconnection of surface and underground waters, levels of heavy metal concentration, radionuclides and other harmful substances in surface and underground waters. These investigations will allow us assess the role of waters in the development of water salinization and overwetting process and etc.

Total time of the preliminary period connected with environmental information is from 3 months to 6 months.

After the existing information analysis the maps must be constructed:

- map of special engineering-geological zoning. This map is constructed on the base of basic maps – geological, engineering-geological, hydrogeological and geomorphological (fig 2.1.2).
- map of anthropogenic territory development and map of environmental anthropogenic impact. This map is very important for monitoring system. It allows show up ecologo-geological danger areas (fig 2.1.3).

To carry out monitoring investigations it is necessary to make reconnaissance inspection of the study area by the use of individual lines to identify the natural environment specifics and manmade loads having an effect on it. The geomorphological, soil, geobotanical, hydrogeological and other necessary observations are carried out to define more exactly the places of the natural environment object selection and also the places of location of wells and prospect holes in individual lines.

Planning of the study testing object condition and dynamic experiment is to identify nature environment sampling places concerning pollution sources, to make time schedule, to choose analysis methods. Long-term observation is sampling, their transportation, sample preparation, sample analysis in the lab, background pollution observation.

It is necessary to support and make monitoring network, chose and equip etalon sections, observation points and profiles. Along with materials obtained previously it is necessary to carry out additional investigations. Investigation methods required to carry out the monitoring are identified subject to concrete natural territorial complex, landscape-soil, geomorphological, geochemical and other conditions.

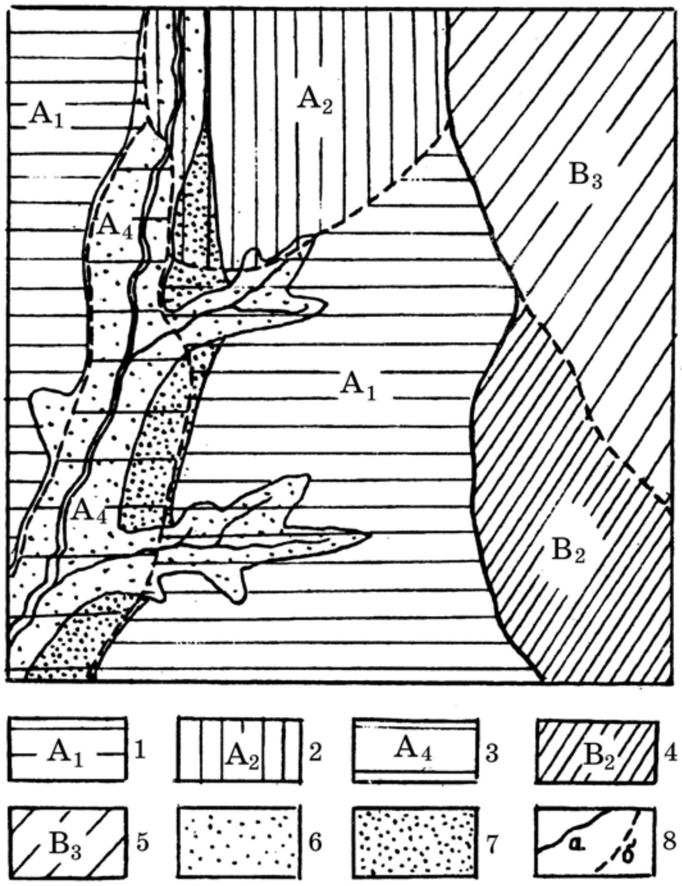


Fig 2.1.2. Schematic map of the special engineering-geological territory zoning development (fragment):
1–5 – districts and subdistricts and their numbers; 6 – alluvial deposits of flood-plain; 7 – alluvial deposits I of terrace above the flood-plain; 8 – boundaries of districts (a) and subdistricts (б) (Королев, 1995)

The following types of methods (atmogeochemical, lithgeochemical, landscape, geobotanic, biochemical, medical-geochemical, hudrogeological, hydrogeochemical, hydrolithogeochemical) are applied when the monitoring is carried out. Every method will be studied more detailed.

Different stations of ground-based and also remotely sensed observations are used to collect information and samples.

Ground-based stations. Observational network including the system of stationary and mobile observation sites (posts, stations, sampling places on the study territory and etc.) is the base of data collection.

Using *remote (especially space) methods* allows us get the nature systems information, show anthropogenic changing, establish regularities of their dynamics in space and time. They include space platforms and board measurements.

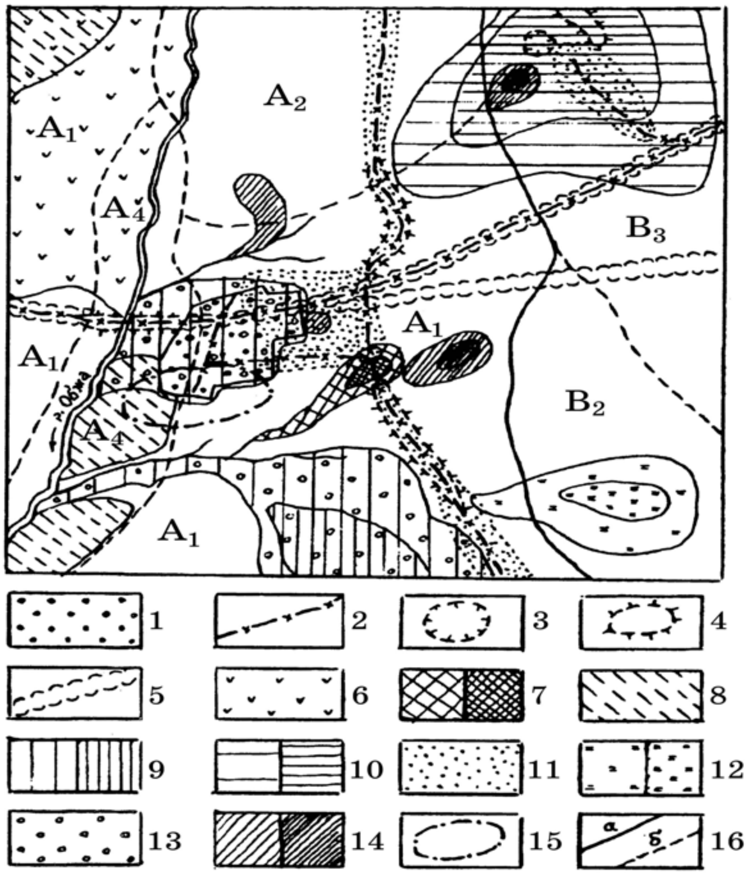


Fig 2.1.3. The map's fragment of anthropogenic geological environment impacts
Mechanical effect: 1 – static compaction; 2 – vibrocompaction; 3 – trench excavation; 4 – banking. Electromagnetic effect: 5 – inducing of electric fields. Chemical pollution: 6 – herbicidal; 7 – hydrocarbon (mild, severe); 8 – salinization; 9 – waste waters (mild, severe); 10 – cement dust (mild, severe); 11 – heavy metals; 12 – nitrate. Biological pollution: 13 – bacteriological; 14 – microbiological. Hydrodynamical effect: 15 – pumping out; 16 – boundaries of districts (a) and subdistricts (б) (Королев, 1995)

Satellites could play a key role by providing efficient methods for measuring spatial environmental changes at local, regional and global scales and over varying temporal scales. They could also be useful in conducting rapid pilot studies such as providing quick and accurate spatial coverage and in recording the locations of the collected samples. These satellite techniques could also play a vital role in implementing management actions and in auditing environmental plans. For coastal management plans, for example, they could be used to located areas prone to erosion caused by variations in shoreline position, thereby leading to preventive actions being taken. For auditing purposes, for example, they could be used to indicate the locations of effluent from a given factory. Such spatial information can then be used to study the ecosystem at the particulate location (Awange, 2012).

2.2. Observational networks and the scope of work

The observation networks which allow provide gathering of reliable information about the whole environment and its certain components are the base of the geological and ecological information gathering during the monitoring. Subject to scope of investigation and geological monitoring category there are detailed, local, regional and national observation networks.

During detailed monitoring the investigation area is determined by taking into account outline of the license areas, and also industrial area, sanitary protection zone of given region.

Subject to purpose the four main groups of observation (inventory, retrospective, operation, methodical) are used in environmental monitoring.

Inventory observations deal with inventory in an appointed period and can be carried out one time a year (or 2-3 years and more).

According to time and periodicity of monitoring carrying out r**etrospective observations** can be different. It depends on rate of change of one or other geological element. Stratified formations such as tree rings, peat, bottom sediment, glaciers can be the subject of these observations.

Operation stationary observations are observations of process dynamics of process at observational points, stations. They show certain temporary (yearly, seasonal, monthly, daily) variation in the observational object and process system.

Methodical observations are necessary to improve monitoring methods or to organize new ones. Very often methodical observations precede operation observations or retrospective observations to correct or make more exact the observations program.

The point of observation – point of soil sampling, spring, borehole, well – is the lowest base unit of hierarchical system of geological monitoring. Next level – observation post (hydrogeological, engineering-geological, geocryological, geophysical and etc.) consisting of the group of phased equipped inspection wells. The post usually supplies only one group of observation, and in case of complex observation methods (for example, hydrogeological and geophysical) it develops into **the observational test site**. The system of observational wells and experimental grounds meant for study of hydrogeological, engineering-geological and geocryological processes is equipped within the observational test site limits.

There are kinds of observational networks:

1. *Areal system of observation* provides even collection of points for agricultural territories, territories of settlements observation in case of some pollution sources.

2. *Linear system of observation* is applied inline. In the line with linear net the observations are carried out on background areas, along the highways, railways, petroleum pipelines and etc.

3. *Vector (radial) system of observation* is applied to study one pollution source, the investigations are carried out in the line with vectors. If the investigations are carried out throughout the four corners of the earth, the vector net is called radial. The vector directed at wind rose can be longer others.

4. *Point system of observation*. Isolated point of natural environment sampling is a point of observation. It can be equipped as observational post.

The schematic map (a fragment) of the territory monitoring observational network is shown in fig. 2.2.1.

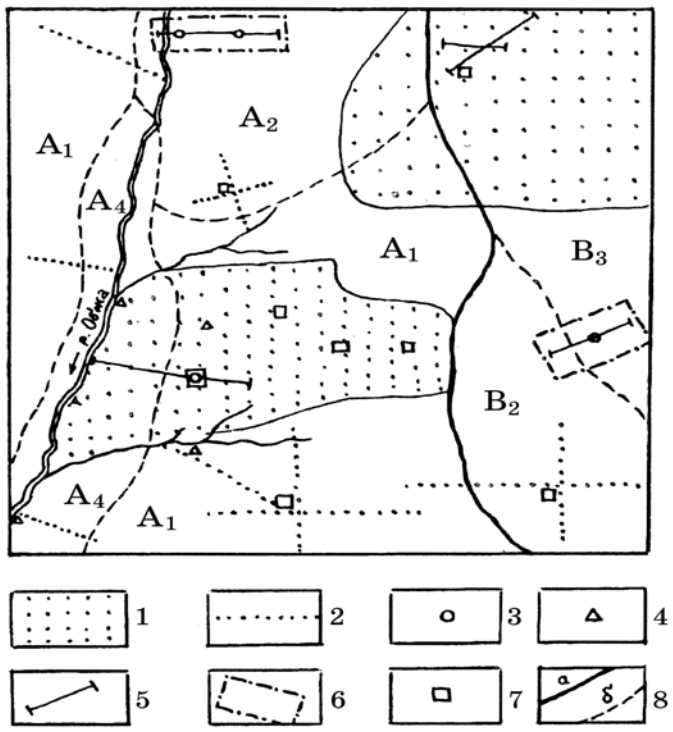


Fig. 2.2.1. The map's fragment of the geological environment monitoring.
Observation network: 1 – area point observation; 2 – line point observation; 3 – observation well cluster; 4 – hydrogeological post; 5 – geophysical profile; 6 – baseline observing site; 7 – observational station; 8 – boundaries of districts (a) and subdistricts (б) (Королев, 1995)

Its legend was developed according to the observational network component classification applied to given scale of plotting. The sectors of zoning are shown on the schematic map. The examined here as an example the preparation procedure of the geological monitoring map shows only general diagram of mapping.

In each specific case however this scheme as well as the information shown on these maps can change.

The scope of work and number of monitoring samples are determined by the observation network. The distance between two points of required observation is changed subject to area and scope of the work.

Extension of observation network is carried out if we have: a) complex landscape, 2) some big and distant pollutants, 3) different ways of input of contaminants, 4) other difficult ecological environments.

It should be remembered that in some cases outside the sanitary protection zone it is much better to make the most efficient use of the testing vector system taking into account the predominate wind rose.

The choice of natural environments in testing points is determined by concrete situation and it can be both complex and individual.

After nature environment sampling the sample preparation to analysis is carried out directly in the laboratory. The sample preparation is individual for every nature environment.

The quantitative analysis is carried out in laboratory environment. The choice of analysis methods is specific in every case and it depends on investigation problems, but we can mark out some general requirements: expresses, specificity and sensitivity. The quality test of laboratory researches is carried out according to data obtained in the laboratory (3% of total amount) and data obtained as a result of outside control (5% of total amount).

Thus, the different methods such as nuclear-physics (spectrometric, radiometric, radioactivation, neutron activation, X-ray fluorescence, radiographic), optical (atomic absorption, emission spectrum, atomic emission spectrometry with inductively coupled plasma, mass-spectrometry with inductively coupled plasma), physicochemical (electrochemical, potentiometric, chromatographic) are used at present.

2.3. Environmental quality

An emission standard is generally used to indicate *the maximum amount (rate or concentration) of a particular pollutant* that may legally be released into the air from a single pollutant source. Emission standards can also refer to the legally enforceable regulations that stipulate the allowable rate of emissions into the atmosphere. Emission standards are a subset of *effluent standards* which involve effluents that are released into the air.

Emission standards are one of a number of strategies used to control air pollutants (other strategies include ambient air quality standards and cost-benefit methods) (table 2.3.1).

Although emission standards can be used independently of other air pollution control techniques, they are often used in conjunction with other strategies as part of an overall air quality management program.

Table 2.3.1

Maximum permissible concentrations of contaminant in Russian Federation and atmospheric air quality criteria in the EU, the USA and WHO

Contaminant	Time of averaging	Russia, mg/m^3	WHO, mg/m^3	USA, mg/m^3	EU, mg/m^3
CO	15 min.	–	100	–	–
	30 min.	5	60	–	–
	1 hour	–	30	40	–
	8 hours	–	10	10	10
	24 hours	3	–	–	–
NO_2	30 min	0,2	–	–	–
	1hour	–	0,2	–	0,2 It must not be above more than 18 times for the year
	24 hours	0,04	–	–	0,12 It must not be above more than 3 times for the year
	Average for the year	–	0,04	0,1	0,04
O_3	30 min.	0,16	–	–	–
	1 hour	–	–	0,235	–
	8 hours	–	0,12	0,157	–
	24 hours	0,03	–	–	–
SO_2	10 min.	–	0,5	–	–
	30 min.	0,5	–	–	–
	1 hour	–	–	–	0,350 It must not be above more than 24 times for the year
	24 hours	0,05	0,125	0,365	0,125 It must not be above more than 3 times for the year
	Average for the year	–	0,05	0,08	0,02
PM10	30 min.	–	–	–	–
	24 hours	–	–	0,15	0,05 It must not be above more than 3 times for the year
	Average for the year	–	0,05	0,08	0,02

Emission standards may apply to both mobile and stationary sources and establish permitted emission levels for all members of a specific group of emitters.

Such standards can regulate these groups at the local, regional, national, or even international levels. Development of effective and efficient standards necessitates a thorough investigation and evaluation of the type of pollutant to be controlled, the number and location of sources involved, the sensitivity and detection limits of analytical equipment available to measure pollutant concentrations, and the effectiveness of current control technologies.

A number of countries have also used the concept of emission standards as a means to address their air pollution problems. Many European nations have set limits similar to those implemented in the United States on the concentration of pollutants that can be present in motor vehicle exhaust. In addition, a variety of countries have attempted to regulate the concentration of hazardous air pollutants in the air through the imposition of emission standards for such pollutants.

As is evident from the above discussion, emission standards can be of several different types or expressed in a number of forms (fig 2.3.1).

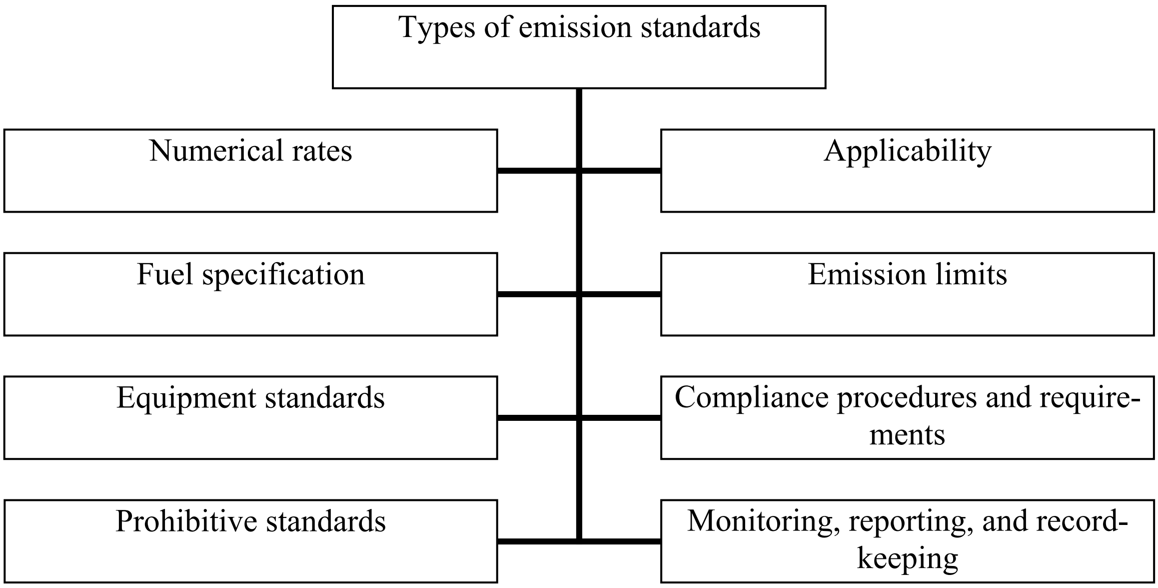


Fig 2.3.1. Types of emission standards in European nations and United States (Environmental geology, 1999)

Ambient air and water quality standards are levels of pollutants that are officially permitted in the receiving air or water.

Each of the designated uses for a water body will have an associated list of chemical, biological and physical characteristics that must be met in order for that use to be sustained. For example, medical research has established that water with less than 0.01 mg/L lead is generally safe for human consumption. That value is a *criterion*. Each of the designated uses for a water body will have many different criteria. For example, in addition to the lead criterion there are drinking water criteria for mercury, nitrate and fluoride and many other substances. Criteria, *per se*, have no legal weight but they are useful in establishing regulations. In the case of drinking water, these criteria have become legal standards. In other cases the criterion may not have legal weight but it may help establish standards for different uses. For example, criteria of optimum water temperature for growth of a given fish species may help establish standards for water discharge temperatures from power plants.

A *standard*, in contrast, is a politically determined judgement that applies to a given physical resource, not to a given use. Standards are the legal mechanism for controlling water quality and water quality management. They represent the application of a series of criteria and a series of desired uses to a given water body (Environmental geology, 1999).

At present in Russia the following groups of standards – sanitary-hygienic, ecological, industrial and economic – are used in monitoring (fig. 2.3.2).

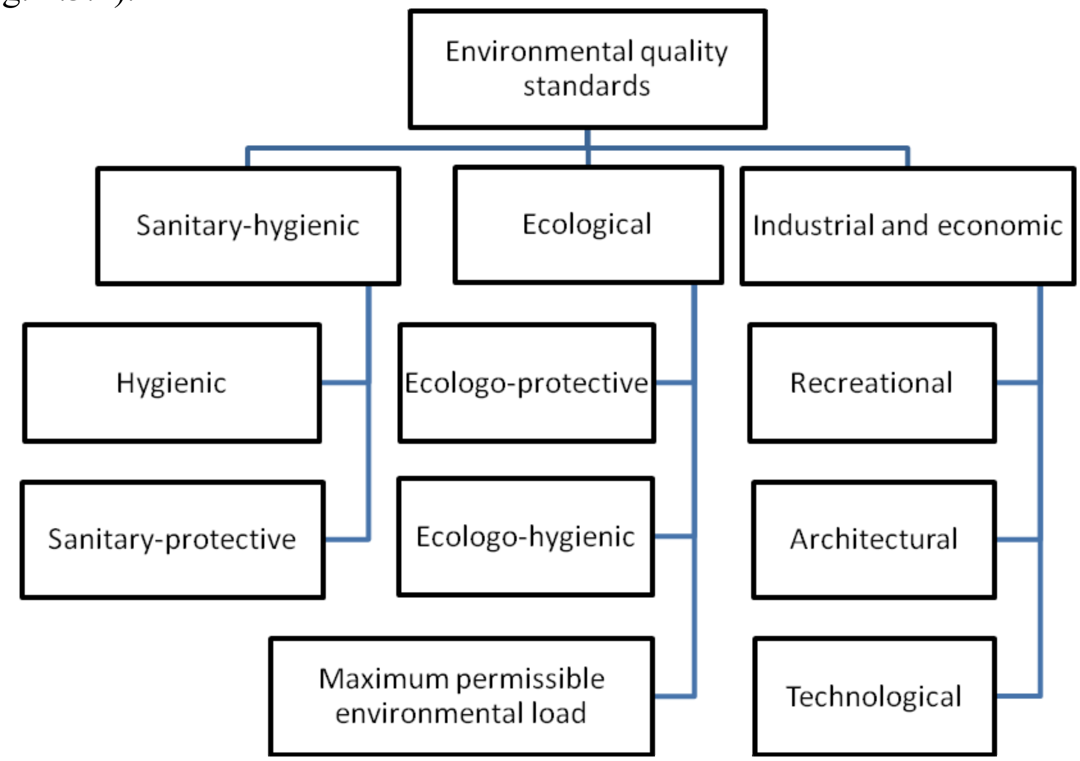


Fig 2.3.2. Classification of environmental quality standards in Russia (Нестроева, 2005)

Sanitary and hygienic standards identify environment quality with respect to human health, but they don't point at source of influence and don't regulate its activity.

Standards of maximum permissible concentration (MPC) refer to sanitary and hygienic indicators. It means that the highest concentration of hazardous substance for exposure time does not have an influence on human health and progeny and also it does not have an influence on components of ecosystems and natural communities in whole. Standards of maximum permissible concentration were developed for atmospheric air, water bodies, and soils. Data of maximum permissible concentration of substance in natural environments are written in documentation which is called sanitary-hygienic standards. For instance, data of maximum permissible concentration for soils are shown in table 2.3.2.

Table 2.3.2

Maximum permissible concentration of heavy metals in soils of Russian Federation, mg/kg(Russian hygienic standard)

Metal	APC (MPC)	Element form
As	2,0	Total ratio
Hg	2,1	»
Pb	32,0	»
Pb + Hg	20,1 + 1,0	»
Cr (VI)	0,05	»
Mn	1500	»
V	150	»
Mn + V	1000 + 100	»
Sb	4,5	»
Cu	3,0	Movable joints
Ni	4,0	»
Zn	23,0	»
Co	5,0	»
Cr	6,0	»

Note: APC – approximately permissible concentration is formed for movable element forms, MPC – maximum permissible concentration.

Requirements presented to the impact source show *industrial and economic standards*.

Maximum permissible environmental load – standards of maximum permissible emission (MPE) and maximum permissible discharge (MPD) and also technological and architectural code of practice containing environmental requirements – is belonged to them.

Technical and industrial regulation shows maximum permissible flows of harmful industrial contaminants passing to air, water and soil. Technical and industrial environmental impact standards are developed for industrial facilities in the form of MPE and MPD projects. *Ecological standards* set limit to harmful permissible anthropogenic environmental impact. To go beyond the limit of harmful permissible anthropogenic environmental impact is to produce threat to optimal conditions of man and environment coexistence.

According to the normative document approved by Ministry of Nature of Russian Federation (30.11.1992) “Criteria for assessments of territories environmental situation for determination of the ecological disaster area” ecological situation can be classified in conformity with increase of the ecological problem level in the following way:

1 – relative satisfactory;
2 – stained;
3 – critical;
4 – crisis (or zone of extreme ecological situation);
5 – disastrous (or zone of ecological disaster).

Choice and justification of criteria for assessment of geological environment changes is one of the main question in methodology of geological environment impact assessment (GEIA). According to V.A. Korolev (1995) all variety of partial criteria of GEIA are combined in five groups: Geochemical, Engineering-geological, Hydrogeological, Geomorphological, Resource. Some basic geochemical indicators used for assessment of different types of geological environment pollution are shown in table 2.3.3.

Table 2.3.3

Indicators of assessment of types of geological environment pollution (Королев, 1995)

Subclass of impact	Type of impact	Indicators of geological environment change	Units of measurement
Radioactive	Short-lived radionuclides Long-lived radionuclides	Exposure rate of gamma radiation at a distance of 10 cm out from the source Specific alpha-activity Specific beta-activity	mR/hr Ku/kg Bk/kg Ku/kg Bk/kg
Chemical	All types	coefficient concentration Coefficient of anthropogenic geochemical load Total pollution factor Anthropogenic contamination module Anthropogenic contamination gradient	mg/kg·m
Biological	Microbiological pollution Bacteriological pollution	Coefficient of microbe concentration Coefficient of bacterium concentration Bacterial indices	

2.4. List and materials content

The next stage of monitoring organization is a stage of the formation complex ecological assessment of environmental components. This assessment includes the formation of observation objects and impact sources database, primary data bank about harmful effect sources. The goals of this stage are geological changes and natural-anthropogenic complex fixation, situation assessment, its analysis, modeling and development of management recommendations.

At this stage the incoming information is analyzed, ecologo-geological maps and reports are made, different situation modeling are carried out, recommendations are developed and preventive measures (repair of equipment and etc.) are carried out. It is made a comparison with, water and soil emission standards, background characteristics as well; geochemical characteristics are calculated. It is made a comparison with early carried out measurements to show up regularities and to make projections.

The application package *Statistica, Mathematika* is the basic software tool, applying for projection and statistical data manipulation.

In conformity with monitoring investigations different thematic maps and scheme showing modern status and environmental components changes. As a basic geological information system (GIS) allowing represent environment in cartographic style, GIS is used.

In the line with monitoring the maps (required and auxiliary) are made. **The required** maps are**:**

- geoecological (the basic paper of monitoring);
- geochemical;
- hydrogeochemical;
- underground water protection;
- geological environment prognostic;
- geological environment assessment and nature protection zoning.

Take up some of these maps.

Geoecological map. Background and abnormal contents of elements and compounds are showed with solid and broken painting. The contaminant concentration anomalies from standardized by State Standard are showed for underground waters and soils. The areas of different types of exogenous geological processes and their intensity are showed with the different kinds, slope and color of hatching.

Hydrogeodynamic map. Anthropogenic changes of hydrogeological conditions, lines and parameters (cone of depression, backwater zones of underground waters, anthropogenic areas of underground water recharge and underground water discharge) are showed with contours and marks. Areas where temperature, mineralization, chemical composition change of underground water, hydrogeological processes rate (infiltration, changes of underground water level) occurred they are showed with contours and marks.

The map of geological environment assessment and nature protection zoning is necessary for the geoecological information users and in the first place for product design people. It is recommended to pay attention to three categories of territories with various broken condition of geological environment: weakly-, middle-, intensive changed. To show ecological situation it is recommended to use contours painting on the principle of «traffic light»: green – favourable, yellow – less favourable, red – unfavourable.

***Additional maps*:**

- landscape;
- monoelement (distribution of element concentration in the nature environment);
- geochemical association schemes;
- auxiliary;
- map of permeability of strata of aeration zone;
- map of certain exogenous geological process;
- map of actual material;
- map of anthropogenic load.

The types of relief and landscape are showed on *the landscape map*. The points of sampling, monitoring points are showed on *the actual map*. The concentration of certain elements in mother rocks, soils, aerosol, atmosphere, surface and underground waters, flora, biogenic mass are showed on *the monoelement map.* On this map the isolines show areas with different content of one or another component (in absolute or normalized contents to background or MPC).

The geochemical association map. There are areas (fields) which characterizing with development one or other metal associations (it shows that they belong to one pollution source) or toxic level (it shows different danger level of areas).

The auxiliary maps show the distribution of different quantity characteristics in testing environments and show the complex anomaly contours.

The prediction is realized on the base of facts. The object changing prediction is carried out of on base of informational models and data obtained experimentally. For example, the water pollution increase or decrease, atmospheric air with production capacity changing, the after purification putting into operation, replacement of production process technologies. Different mathematical and physics models are used to show dynamics.

Software tools GMS 3.0 (Groundwater Modeling System) are used to form permanent geofiltration and geomigration working model. GMS is the most complex program package which is provided with required tools for every phase of underground water modeling.

As for *implementation management* actions is a development of nature protective procedure which includes the factories equipment modernization. The users of resulting information are plant facilities, environmental monitoring national services. Obtained information is presented as a report, in the informational bulletins. The text preparation for information publication is done in MS Word, table materials – in MS Excel. Report and output documents preparation is done in Microsoft Office.

Revision

Review the questions:

1. Characterize lead time of carrying out the environmental monitoring program.
2. Enumerate basic methods of monitoring.
3. What types of observational networks are used when carrying out environmental monitoring?
4. How is processing of analytical result carried out?
5. What are development and implementation of managerial decisions by monitoring results carried out for?

Answer the following questions:

1. Observational networks can be:

a) pointed; b) linear;
c) rectangular; d) vectorial;
e) areal; e) single.

2. Name the main groups of standards used in the monitoring investigation practice and give a definition of them:

a) sanitary and hygienic; b) biological;
c) ecological; d) industrial and economic.

3. Mark the main groups of environmental observations:

a) inventory; b) areal;
c) retrospective; d) stationary;
e) controlled; f) impact;
g) methodical; h) distant.

4. The level of ecological problem can be:
a) moderately satisfactory; b) relatively satisfactory;
c) strained; d) not critical;
e) critical; f) crisis;
g) disastrous.

5. What criteria of geological environment impact assessment are there:
a) Hydrogeochemical; b) geochemical;
c) mathematical; d) engineering-geological;
e) lithogeochemical; f) hydrogeological;
g) geomorphological; h) resource.

3. NATURAL ENVIRONMENTS MONITORING

3.1. Atmosphere monitoring

3.1.1. Atmosphere pollution sources

Air pollution is regarded as the presence of harmful substances in the atmosphere (table 3.1.1.1). The pollutant must be present in quantities or for periods of time that affect humans, animals, plants, materials or our perception of the environment.

Table 3.1.1.1

Some air pollutants (Environmental geology, 1999)

Pollutant	Sources	Health effects	Behavior
Sulfur dioxide	Coal burning, metallurgy	Bronchitis, asthmatic sensitive (H_2SO_4)	Affects plants (20–40 ppb), weathers metals, building stone
Nitrogen oxides	Combustion, vehicles	Altered lung function and lesions; increased respiratory illness	Involved in photochemical smog production
Carbon monoxide	Automobile engine	Displaces oxygen from hemoglobin; neurological effects and increased angina frequency	Reacts with OH radical
Ozone	Photochemical smog reactions	Eye, nose, throat irritation; decline in lung function	Damages vegetation
Volatile organic compounds	Gasoline use	Some are carcinogens (e.g., benzene)	Important in producing photochemical smog and PANs
Polycyclic aromatic hydrocarbons	Diesel motor vehicles and coal burning	Some are carcinogens (e.g., benzo(a)pyrene)	In gas phase or bound to particles
Particles	Diesels, power plants, industry, coal burning	Fine particles cause respiratory illness; enhanced effects in presence of sulfur dioxide	Soiling and degradation of visibility; may contain toxic or catalytic metals and act as sites for chemical reactions

Detrimental effects are at the heart of the definition, rather than the idea that the pollutant is a product of human activities, because occasionally air pollutants are produced by natural sources such as volcanoes. In industrialized countries, deposition of heavy metals from the atmosphere is considered significant. This is mostly due to anthropogenic combustion activities which have substantially enhanced natural emissions of selected heavy metals to the atmosphere (Environmental geology, 1999).

Iron and steel enterprises, energy industry, chemical industry, oil-refining industry, fertilizer manufacturing plants are the main source of industrial pollution of atmospheric air (Берлянд, 1975; Методические ..., 1990).

Industrial pollution sources of atmospheric air are subdivided into emission sources and discharge sources. The technological facilities (apparatus) belong to the first ones. Impurities are given off in the process of operation. Smoke stacks, air pits, aeration lamps and other devices belong to the second ones. With a help of them impurity arrives in atmosphere.

Industrial emissions are subdivided into organized industrial emissions and disorganized industrial emissions. <u>*Organized industrial emission*</u> arrives in atmosphere through the special constructed smoke flues, air duct and smoke stacks, and it allows to applied them to clean from pollutants. <u>*Disorganized industrial emission*</u> arrives in atmosphere in the form of undirected gas stream. It occurs in the result of break of air tightness equipment. Disorganized industrial emissions are typical for treatment facilities, ashpdisposal area, loading and unloading, oil cargo pier, reservoir.

3.1.2. Arrangements for atmosphere monitoring in Russia

Atmospheric air observation is carried out on areas of intensive anthropogenic influence (in cities, industrial and agro-industrial centers) and on territories removed from pollution sources (on baseline territories).

State system of atmospheric air observation and monitoring is a component of state system of environment observation and monitoring. Atmospheric air monitoring is carried out according to the Law of Russian Federation "Atmospheric air protection" ("Об охране атмосферного воздуха)" and state standards. Atmospheric air monitoring is also carried out according to regulations and State Standards.

The atmosphere pollution level in Russia is carried out by territorial form of government of Federal hydrometeorology and environmental monitoring service. In addition, observations are carried out by some authorities, and also by the enterprises and establishment ecological services.

State system of atmospheric air observation and monitoring consist of two levels of monitoring:

- impact monitoring – emission source monitoring directly on plants (monitoring of sources). Measurement of contaminants is carried out in air of working area. Sampling works are placed on the boundary of sanitary protection zone of the plant and in impact area of the plant in accordance with predominant wind direction;

- regional monitoring including baseline monitoring.

The regional monitoring network includes three types of stations:

1) stations, which are situated in regions subjected to anthropogenic impact;

2) region stations for background observations in intermediate regions where pollutant come by local dispersal movements;

3) contributing stations for background observations in regions, where components-contaminant are found as a result of global spreading. Background monitoring network situated on the territory of our country is included in *Global environmental monitoring system*. So, for example, according to the international agreement the base and regional station must be placed at the distance 40–60 km from the large pollution sources on the leeward side. On the territories joined to the station within a radius of 40–400 km the nature of human activity must not change. It was recognized that air samples must be sampled at a height of less then 10 m above the greenery.

In Russia stations are subdivided into 3 categories:

- stationary post;
- route post;
- mobile post.

So, a **stationary observation post** is an especially equipped pavilion with apparatus which is necessary to register contaminant concentration and meteorological parameters in line with the established procedure. Sampling is carried out at a height of 1,5–3,5 m above the ground surface.

The observations can be carried out either complete monitoring program or reduce monitoring program (table 3.1.2.1).

When complete monitoring program is used one-time concentrations and mean daily concentrations are recognized. To determine one-time concentrations contaminant sampling time covers 20 min. Mean daily concentrations measurement is discrete at 1, 7, 13, 19 h. local time by following averaging. *Incomplete program* is daily observation at 07, 13 and 19 h. to obtain the information about contaminant one-time concentrations. *Reduce monitoring program* is carried out to determine daily one-time concentrations at 7 and 13 h. local time. Transition to reduce monitoring program is allowed at –45 °C and in places where mean monthly concentrations of contaminant are reduced more then 20 times in comparison with maximum permissible concentration (MPC).

Table 3.1.2.1

Programs of measurements at the stationary post (РД 52.04.186-89)

Monitoring program	Time measurement	Receiving information about contaminant
Complete	Every day at 1, 7, 13, 19 h. local time	One-time concentrations, mean daily concentrations
Incomplete	Every day at 7, 13 и 19 h. local time	One-time concentrations
Reduce	Every day at 7 и 13 h. local time, at – 45 °C, mean monthly concentrations of contaminant are reduced more then 20 times MPC	

In Russia there is stationary network which observes pollutant contaminant in atmosphere. They are situated in 253 towns, on the average 2 stations in a town. About 2/3 of urban population is under observation. The number of stationary posts depends on population of a town, settlement area, land topography and industry level. Regulations of monitoring of settlement and urban air pollution level are given in State Standard (GOST) 17.2.3.01–86 (table 3.1.2.2).

Table 3.1.2.2

Number of the stationary posts-population size dependence

Population size	Number of posts in Russia GOST 17.2.3.01-86	Number of posts in countries of EU EU Directive 2008/50/EU 21.05.2008
to 50 000	1	1
50000–100000	2	1
100000–200000	2–3	1
200000–500000	3–5	2 (250000–499000)
500000–1000000	5–10	2 (500000–749000)
over 1000000	10–20	3 (750000–9990000) 4–9 (1000000–5900000)* 10 (over 6000000)*

Note: * – two times less in towns with lower pollution level

Standard pavilion-posts and complete laboratories (type POST) are produced by native industry to provide optimal conditions to carry out stationary observations. Inside a post is equipped with automated devices. This laboratory includes the meteorological parameters measurement system, the sampling system (for the following analysis in the laboratory), the automatic system to measure contaminants with a help of gas analyzers and dust counters, the heating system and the lighting system (fig. 3.1.2.1).

Generally the atmospheric air stationary observation posts are located on the typical pre-tested most intensive pollution areas, in residential zones and recreational areas and also at the demarcation line of enterprises sanitary protection zone. In line with State Standard the number of stationary observation posts are determined subject to population in town, the area of human settlement, land configuration and industrialization level.

Fig. 3.1.2.1. Stationary post of atmospheric air observation (www.yandex.ru/photo)

The observation of the main contaminant (dust, sulphur dioxide, carbon oxide, nitrogen dioxide) content and specific substances which are typical for this territory. In all there are 38 substances.

There are 6 stationary posts in Tomsk. There are 13 contaminants (dust, sulfurous anhydride, carbon oxide, nitrogen dioxide, nitrogen oxide, hydrogen sulfide, phenol, soot, hydrogen chloride, ammonia, formaldehyde, methyl alcohol, benzo(a)pyrene) are measured.

At Moscow, St. Petersburg, Cherepovets stationary posts the mean daily concentrations measurements are carried out with continuous sampling during 24 hours with a help of an automatic gas analyzer. The system allows obtain information about impurities concentration and meteorological parameters in settlement or near large plant facilities.

Foreign automated posts (for example, Rancon (Italy), Antechnica (Germany), Thermo Environmental (The USA), Seres (France) and etc.) include most of all:

- chemoluminescent gas analyzer of nitrogen oxides, infrared gas analyzer of carbon oxide, ultraviolet gas analyzer of ozone, flame-ionization gas analyzer of hydrocarbons, fluorescence gas analyzer of sulphur dioxide, radiometric analysis of dust;
- weather station;

- automatic sampler;
- data loader with common software;
- data communication equipment (DCE) IBM-compatible computer (Хаустов, Редина, 2008).

Route observation post is a place on the certain town route. It is meant for air sampling in the fixed site of locality under the observations carried out with a help of mobile equipment. Route observations are carried out with a help of motor car laboratories (fig. 3.1.2.2).

Fig. 3.1.2.2. Route atmospheric air observation post (www.yandex.ru/photo)

The mobile ecological laboratory is equipped with gas-analysis equipment for measurement of priority contaminant (carbon oxide, nitrogen oxides, hydrocarbons, methane, ozone, sulphur dioxide) automatically, apparatus for measurement of meteoparameters, and the system of automatic sampling for sample and next laboratory analysis of those substances which cannot be measured automatically.

The mobile ecological laboratory has got productivity about 5000 samples a year; this laboratory can sample 8-10 air samples a day. In accordance with the sampling the order of route observation post going round is changed monthly. It is changed in this way that sampling is carried out in every point at different time of a day. For example, in first month the car comes to see posts in ascending order of numbers, in the second month – in descending order of numbers, and in the third – from the middle of rout to the end and from the beginning to the middle and etc.

Stationary posts and route posts are located at the sanitary protection zone boundary of enterprises.

Mobile observation post (under plume site) is meant for sampling under the chimney t for the purpose of detection of this source's effect zone. Under chimney (or flare) observations are carried out according to worked out special program and routs for specific contaminant which are typical for this enterprise.

Air sampling is carried out sequentially in the direction of wind at distances in from 10 to 40 times more then height of chimney from the emission stationary source from windward side and leeward side. In maximum pollution zones 60 air samples at least are sampled and in other zones minimum must be 25 at least. Air sampling during under chimney observations is carried out at a height of 1,5 m from the ground surface during 20–30 min no less than in three sites simultaneously.

Such companies as Biotonic (Germany), PPM-systems (Finland), Seres (France), ETI (Germany) are among foreign manufacturers of mobile laboratories. The equipment similar to the stationary post equipment is used in these laboratories.

Thus, mobile laboratories allow to organize environment observation on more immense territories and to provide on-line inspection of point sources of emissions.

Distant measurement instruments are used for monitoring of atmosphere pollution. Lidar systems and systems of aerospace monitoring are the most widespread systems of a pollutant emission monitoring.

Space satellites are used during atmospheric air monitoring. Space information reception regional centers belonging to Rushydromet are situated on the territory of Russia. Also there are automated centers to receive the digital and analog space information, these centers are connected with the regional point by the use of digital communication channel. These automated centers are situated in Moscow, St. Petersburg, Omsk, Novosibirsk, Irkutsk, Ulan-Ude.

The system of **aircraft stations** coupled with mathematical models of spreading impurities is an important method of monitoring of so-called transboundary transport of the moved for long distance global impurity streams. The transboundary transport stations are equipped with systems of gas and aerosols sampling, dry and wet falling out sampling and are also equipped with the system of analysis of sampled impurities content. The information arrives at meteorological synthesizing centers (Хаустов, Редина, 2008).

3.1.3 Atmospheric air monitors, methodology of analytical data processing

Sampling is one of the main components of the atmospheric air quality analysis. If sampling is carried out incorrectly the results of the most careful analysis are useless.

The aspiration absorption of contaminant is more often used method. The aspiration method, based on infiltration of certain account of air, allows to determine aerosols and gas composition; sedimentation method allows to examine aerosol, felt out on the special plane table (dry falling out); and also based on atmospheric precipitations (wet falling out).

Instrumental and calculation methods are used to determine quantitative and qualitative characteristics of the contaminant emissions. The choice of method depends on the nature of production and source type. The choice of monitors is realized according to State Standards.

Instrumental methods are basic to determine sources of organized contaminant emissions in atmosphere. Calculation methods are used to determine characteristics of sources with unorganized emissions.

Acoustic *thermoaniometer* can be used to measure wind rate and direction. *Rheometer, rotameter* and other flow-measuring apparatus are used to register air volume.

Portable Gas analyzers are used to determine gas concentration. We obtain information about gas concentration diurnal variation according to the chart strip recording. The air-permeable apparatus and devices and also apparatus and devices recording air volume are used to sample air.

Aspiration absorption is one of the most frequently used ways of air sampling. Instruments are called *aspirators.* Both sorbents (for gaseous phase) and filters (for aerosols) are used for air sampling. Received samples are carried to the laboratory and they are analyzed according to pollution content. The scheme of air sampling and preparation is shown in fig. 3.1.3.1.

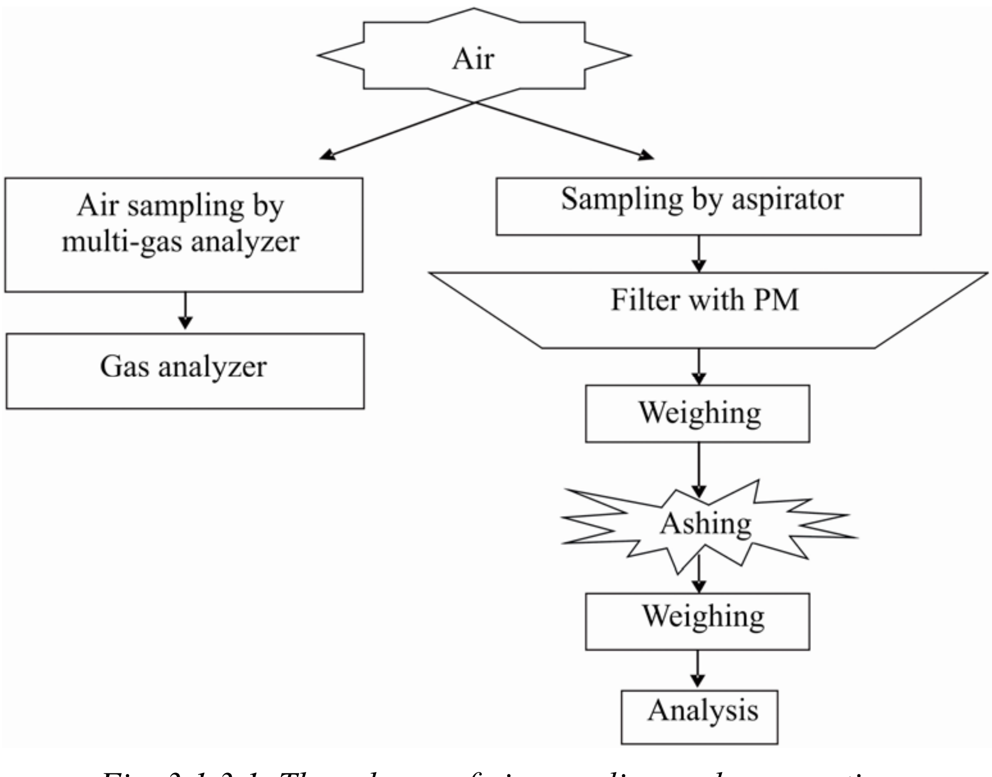


Fig. 3.1.3.1. The scheme of air sampling and preparation

For sampling of dust aerosols with aspirator we pump atmospheric air through the filter. It is necessary to weight the filter before work. Volume of pumped air recording is carried out. Pumping through the aspirator continues 10–15 min. Then the filter with solid particles are taken out and weighted. After that the filter is incinerated and weighted again and then it is sent to perform chemical element content analysis. Analysis choice subject to testing component is carried out in line with State Standard.

Obtained results of contaminant content are compared with maximum permissible concentration (MPC) for atmospheric air or background data.

The **air pollution index (API)** is a simple and generalized way to describe the air quality in Russia. It is calculated from several sets of air pollution data.

The air pollution index is calculated according to the formula:

$API = \sum[C_i / ПДК_i] \times K_i$,

C_i – contaminant content;

K_i – coefficient taking account a class of hazard;

ПДК – maximum permissible concentrations of contaminant.

Values of API show the level of atmosphere pollution:

< 2.5	clean atmosphere;
2.5–7.5	slightly polluted;
7.5–12.5	moderately polluted;
12.5–22.5	heavily polluted;
22.5–52.5	highly polluted;
> 52.5	severely polluted.

Revision

Review the questions:

1. Name the sources of atmosphere pollution.
2. What are the differences between stationary posts and mobile posts of atmospheric air observation?
3. What is the impact atmospheric air monitoring?
4. Characterize atmospheric air monitors.
5. What is the analytical data processing technique of pollutant analysis in atmospheric air?

Answer the following questions:

1. According to what programs are the observations carried out at the stationary posts:

a) complete; b) daily;
c) incomplete; d) reduce.

2. Match the letters with the numbers:

1) stationary post: a) air sampling in the fixed point of locality;

2) route post: b) air sampling under the chimney for the purpose of detection of the source's effect zone;

3) mobile post: c) air sampling in an especially equipped pavilion with apparatus.

3. At what distance from the industrial plant with stationary source of emissions it is necessary to sample of atmospheric air:

a) in 10–30 times more then height of chimney;

b) in 10–40 times more then height of chimney;

c) in 10–20 times more then height of chimney.

4. Mark the instruments used for sample and analysis of the atmospheric air gaseous phase:

a) dust counter; b) gas analyzer;

c) rheometer; d) aspirator.

5. Mark the instruments used for sample and identification of aerosol content in atmospheric air:

a) respirator; b) gas analyzer;

c) dust counter; d) aspirator.

3.2. Contamination monitoring of snow cover

3.2.1. Snow geochemical survey in Russia

Recently natural environments accumulating aerosols have been widely used in the environmental monitoring. In this case snow cover as a natural plane table –accumulator shows real value of dry and wet atmospheric falls in cold season. Low temperatures provide conservation of chemical compounds occupied with snow during whole winter season. Studying of snow cover chemical composition allows to find out the special areas of pollution and to calculate real landscape pollution during the period with stable snow cover.

So, you should understand for the reason that particles being in the air have mainly anthropogenic origin therefore chemical composition show its anthropogenic pollution and also anthropogenic pollution of atmosphere.

In contrast to another natural environment snow is homogeneous and it is formed under similar conditions. In snow the information about pollutants is accumulated with two ways:

1. While snow falling occurs the particles are captured by atmospheric dust i.e. atmospheric scavenging occurs.

2. Dry precipitation, i.e. gravitational dust precipitation in snowless period of time.

When snow forming and falling as a result of dry and wet scavenging, concentration contaminant in snow is in 2–3 orders higher than in atmospheric air.

Works dealing with snow sampling and analysis of snow pollution by different substances are usually called *snow geochemical investigations* or in brief – *snow survey*. *Atmogeochemical investigating method* has been intended for study of background dust load and peculiarities in substantial composition of regional dust-aerosol fall-outs (Weiss, Herron, 1978; Drake, Moote, 1980). Sampling and analysis of snow are carried out according to GOST 17.1.5.05–85, atmosphere pollution monitoring manual (РД 52.04.186–89), methodological recommendations given in works of Vasilenko V.N. and et al. (Василенко и др., 1995), Nazarov I.M. and et al. (Назаров и др., 1978), methodological recommendations (Методические..., 1982).

Possibility of using snow cover as an indirect indicator of atmospheric state in the conditions of large-size urban zone with a number of contamination sources has been proved by experiments carried out by Institute of mineralogy, geochemistry and crystal chemistry of rare elements in cooperation with Institute of petrography on the territory of a large city (Методические …., 1982). A specific of the Siberian region is the deposition of dust-aerosol on the snow cover that lasts here for several months. Thus, a snow cover testing was made at territory of Western Siberia (Язиков, Рихванов, 1996; Шатилов, 2001; Язиков, 2001 and et al.).

Starting from 1980 contamination monitoring of snow cover operates on the base of snow survey of Statecomhydromet, dust and its components fallout data is obtained at former USSR territory (Василенко, Назаров, 1985). *Stationary networks* of Statecomhydromet regional subdivisions are situated at Russia territory evenly both at background parts in the distance from anthropogenic sources and at contaminated territory not far from cities and industrial zones. On the base of generalized data dealt with stationary snow networks maps are made and the direction and capacity of contaminant transportation are determined at territory of Russia. For example, at Siberia territory the snow cover and aerosols composition are carried out with a help of snow survey more than in 500 observation sites.

Snow sampling analysis from stationary network sites is carried out in line with two programs, which differ from one another by components in testing snow samples (table 3.2.1.1). The first program is carried out in labs of all stations, the second one – approximately at 50 % all stations.

Table 3.2.1.1

Components in analyzing snow samples (РД 52.04.186-89)

Name of monitoring program	Analyzing components in snow samples
The first program	1) suspended substances content (i.e. dust); 2) acidity (*pH*) and electroconductivity; 3) content of basic water soluble compounds – sulphates, nitrates, ammonium and chlorides
The second program	1) suspended substances content (i.e. dust); 2) acidity (*pH*) and electroconductivity; 3) content of water soluble compounds – sulphates, nitrates, ammonium, chlorides, potassium, sodium, magnesium, calcium; 4) content of heavy metals and surface active agents; 5) for certain regions – content of number of specific for region compounds

The survey at the temporal expeditionary network is usually carried out at *industrial cities territory* to determine the atmospheric air pollution structure or in *the neighbor of contaminant emission source* to determine impact zones and to carry out contaminant activity monitoring.

Sampling is carried out taking into account relief characteristics and their expositions relative the direction of main wind, and also at the parts of anthropogenic gas-dust emission. When snow sampling is labored because of meteorological conditions the dust-aerosol fallout is carried out using plane table. In whole it is recommended to combine sampling places with sites of basic investigations.

The sites of snowgeochemical expeditionary network are located evenly on observable territory with density which is enough for solving problem.

For snow survey in cities subject to assigned task approaching rectangular network the size of 1×1 km, 500×500 m or 250×250 m is used. Sampling density must provide revealing of the most important pollution focus. In big cities sampling density is recommended 1-5 samples per 1 sq. km. It is used for revealing pollution focuses, dealt with industrial zones or independent large enterprises. To recognize the most polluted territories the sampling density becomes more close 25-30 samples per 1 sq. km.

Scale of snowgeochemical surveying on cities should be 1:50 000, on industrial enterprise territory – 1:25 000, on mining deposit territory – 1:5000.

There are two stages to determine snow cover contamination at the networks:

1) sampling at sites of stationary network;
2) sampling preparation and chemical analysis.

3.2.2. Snow sampling and preparation

Subjected to monitoring goals snow is sampled layer-by-layer or weekly, monthly. Snow sampling is carried out at the end of February or the beginning of March before the intensive period of snow melting.

Snow sampling is done by snow sorter or from holes (pit method) (fig. 3.2.2.1).

Fig. 3.2.2.1 Snow sampling (left – by snow sorter (V. Udachin), right – pit method)

Snow is usually sampled with standard arrangement for snow collection (it is a tube section 70 cm long with toothed bottom edge for slotting of thin crust of ice over snow, it has centimeter scale outside to measure snow cover height). Snow sample consists of some snow cores taken with arrangement for snow collection snow cover whole depth.

Quantity of snow cores in sample is determined on the basis of production conditions of melt water volume. It should be no less 2-3 liters in one sample. If snow cover height is 35 cm quantity of snow cores in sample is 6, and if snow cover height is 80 cm quantity of snow cores in sample is 4. Samples are placed in plastic bags and delivered in chemical laboratory.

Snow sampling is carried out by pit method for the whole thickness of snow cover, except for 5 cm layer over soil, measuring sides and depth of the pit. Firstly pit the size of 30·30 cm is put, then snow is sampled with a help of a porcelain dish or a plastic scoop in the plastic bag full. During sampling pit can be widen to fill whole plastic bag. After sampling the plastic bag with snow is tied with string with label in which is indicated a sample number. Then the pit sides and depths are measured. Sample weight is – 15–20 kg. Sampling site, sampling date, sampling depth and sampling size are logged.

Sample preparation starts with snow melting at room temperature, and then includes the following actions: filtration, drying, dressing and weighing (fig. 3.2.2.2, 3.2.2.3).

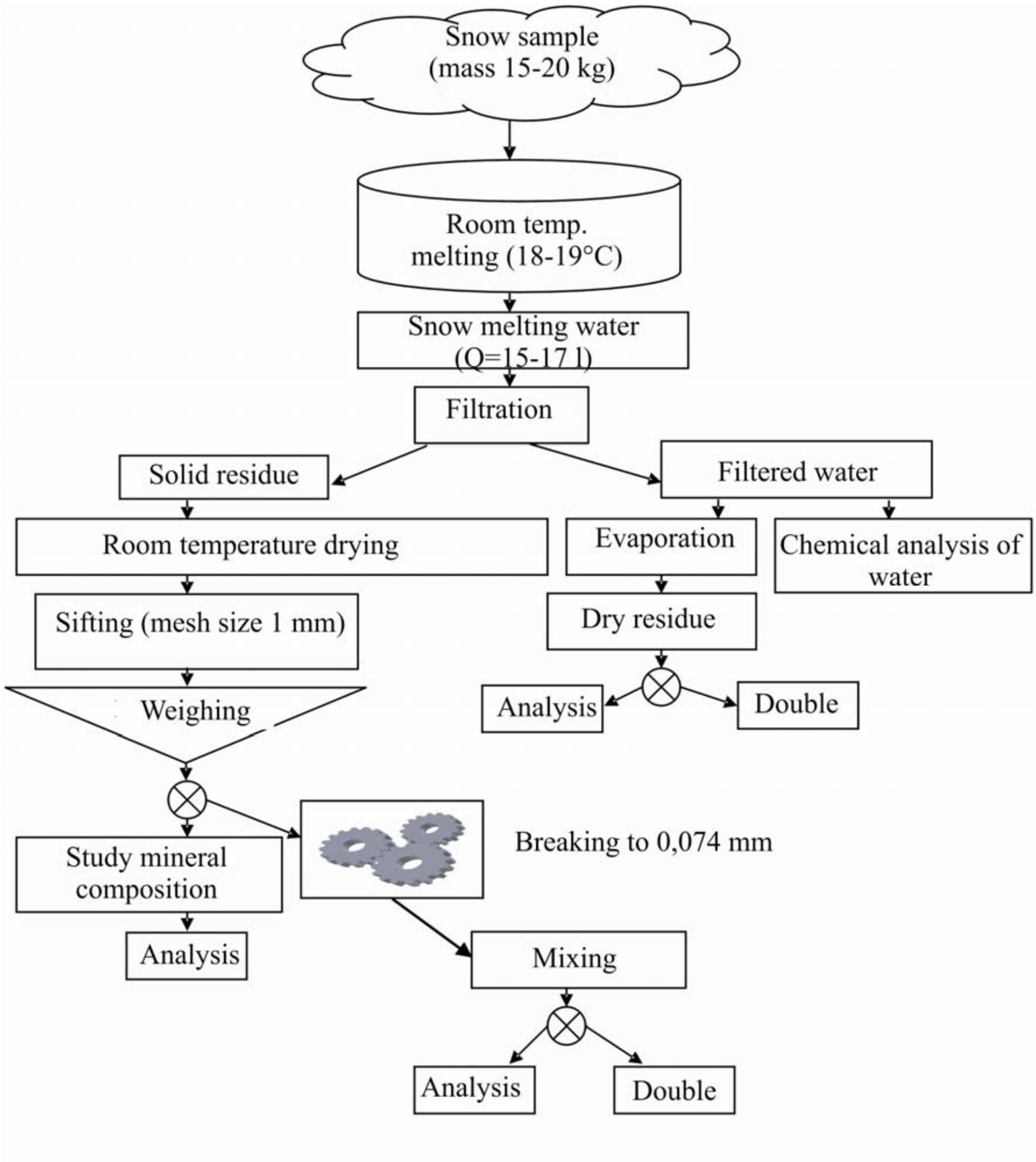


Fig. 3.2.2.2. Scheme of snow preparation

Melting water is filtered, in the process of which the insoluble phase on ash-free filter and melting water are produced. Insoluble phase is isolated by means of ash-free filter and dried out. Dried samples are dressed through the bolt with the size of mesh 1 mm to remove the impurities and are weighed. The difference in the filter mass before and after filtration shows the dust mass in samples.

Snow sample preparation involves separate analysis of snow melting water obtained by melting, and the insoluble fraction of the aerosols in snow.

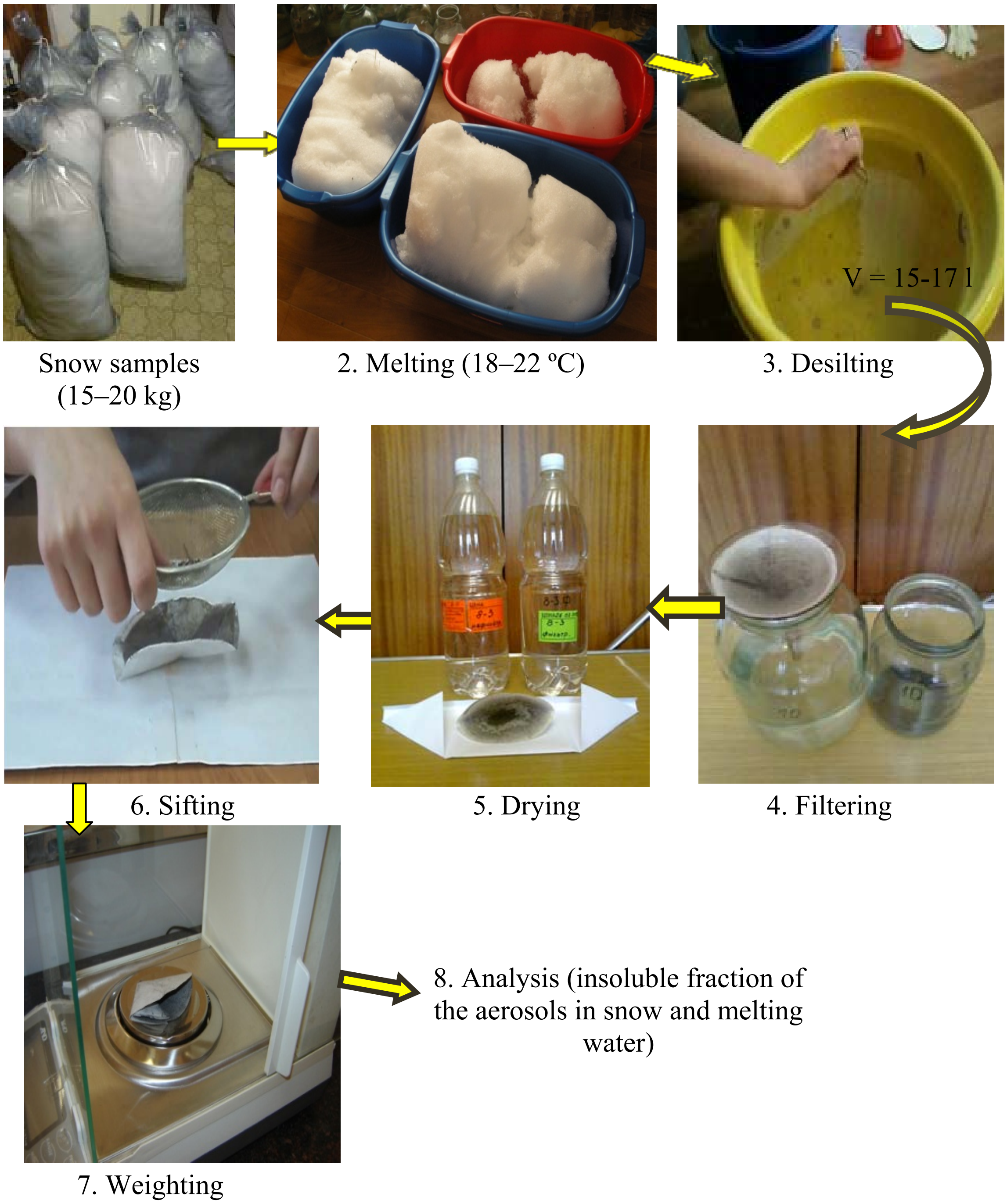


Fig. 3.2.2.3. Snow preparation (photos by authors and Filimonenko E.A.)

3.2.3. Procedure of geochemical data processing

Characteristics of contaminant fallout on territory are determined by results of snowgeochemical survey at field network. Maps with special distribution of contaminant (dealing with an every testing component) and maps connected with integral contaminant index are made.

On the base of obtained information the geochemical characteristics are calculated. Characteristics calculations are calculated according methodic recommendations (Методические …., 1982).

The following factors are calculated by the snow sampling results.

Weight of dust in snow sample allows for determination of **dust load** (P_n) in terms of mg/m^2 per day or kg/km^2 per day which correlates with each other. Dust load is a quantity of solid particles which are settled in a unit of time on a unit of square. Dust load is calculated by the formula (1):

$$P_n = P_o \ / S \times t \qquad (1)$$

P_n – dust load, mg/m^2 per day (kg/km^2 per day); P_o – weight of the snow solid residue, mg (kg); S – square of the pit, m^2 (km^2); t – number of days from snow-up day (the day when snow falls out and does not melt) to sampling day.

Dust load is characterized by the following contamination level and morbidity level:

- less than 250 mg/m^2 per day – low contamination level; safety morbidity level;
- 250–450 mg/m^2 per day – middle contamination level; mildly unsafe morbidity level; increase in bronchial asthma and conjunctivitis;
- 450–850 mg/m^2 per day – high contamination level; unsafe morbidity level; increase in respiratory and sense organs morbidity;

more than 850 mg/m^2 per day – very high contamination level; immensely unsafe morbidity level; increase in morbidity more than 2 times.

According to snow geochemical survey on the territory of Tomsk in 2008 the dust load value changed from 16 mg/m^2 per day to 303 mg/m^2 per day whereas average value was 63 mg/m^2 per day (fig. 3.2.3.1). The comparison of standards (Геохимия …, 1990) the dust load value on the territory of Tomsk changes from low contamination level to middle one.

The most contrast parts of average daily dust inflow per snow cover are situated on the territory of northeastern part of Tomsk where there are main plants of building industry and also they are situated on territory of central part of Tomsk where there is power station.

Concentration coefficient is shown the anomalous of element concentration relatively the background value. It is calculated by the formula (2):

$$KK = C / C_b , \qquad (2)$$

KK –concentration coefficient; C – element concentration, mg/kg; C_b – background value of element concentration or geochemical the noosphere clarke, mg/kg.

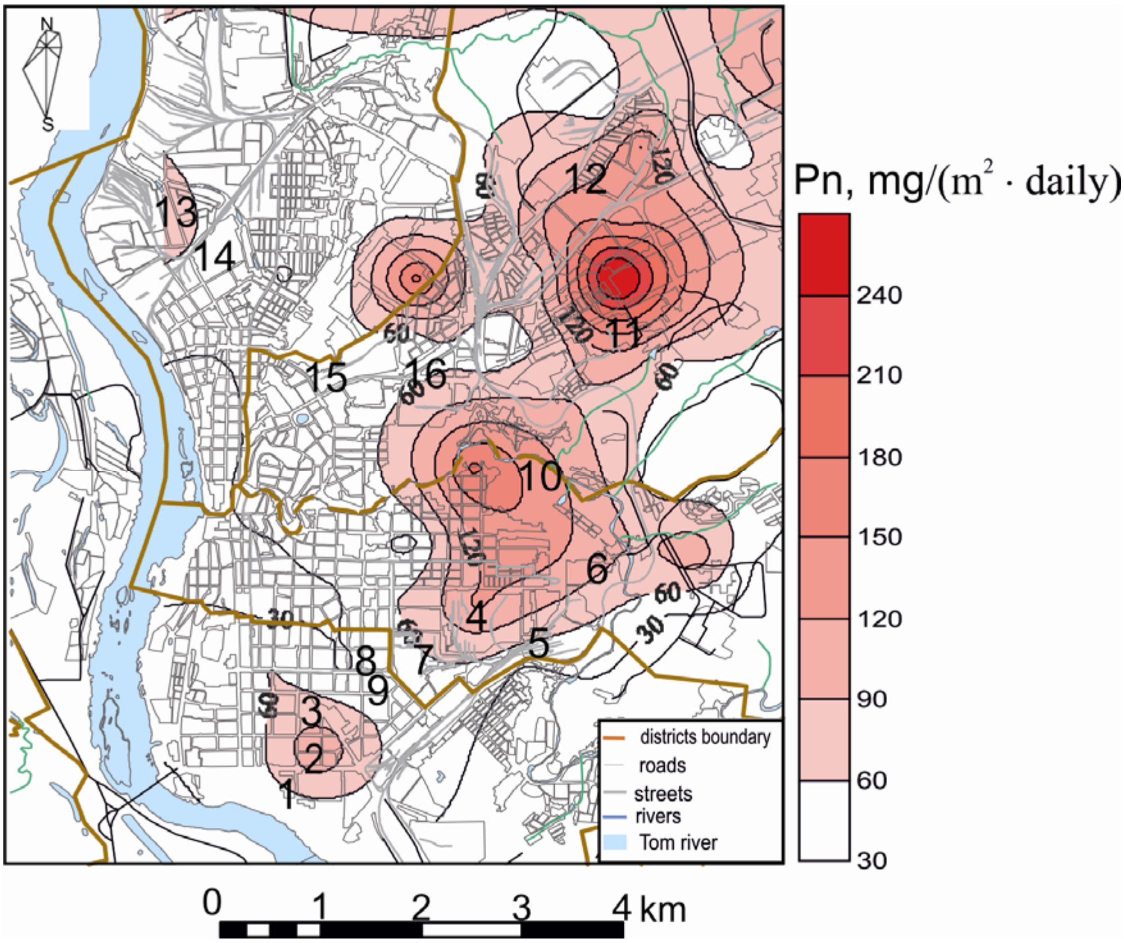


Fig. 3.2.3.1. Average daily dust load value on the territory of Tomsk (2007) (numbers – location of the main plants: 1 – LLC (Limited Liability Company) "Kontinent"; 2 – LtD "Tomsk instrument"; 4 – GRES-2 Tomsk branch of LtD "Territorial'naya generiruyuschaya kompaniya-11"; 10 – ash disposal area of Tomsk GRES-2; 11 – CJSC (closed joint stock company) "Kar'eroupravlenie" (adapted from Таловская, 2008, Язиков и др., 2010)

According to concentration coefficient the geochemical row of element association from the highest value to the lowest value are constructed. If the concentration coefficient is more than 3 it means the local sources have emitted dust with elements. In contract to that if the concentration coefficient is less than 3 dust with elements is related to diffuse pollution. The concentration coefficient helps to determine the dominant elements for dust aerosols which come from different plants.

The concentration coefficient with respect to the background value gives the geochemical characteristic of the studied aerosols in impact areas of several plants in Tomsk (table 3.2.3.1).

Table 3.2.3.1

A number of geochemical elements ranges from the highest value to the lowest one

Impact area	Concentration coefficient			
	More than 10	10…5	5…3	3…1
Construction plants	Tb16.2–U16.1–Yb15.2–As12.7–La11.5	Sm9.9–Ta9.7–Na7.9–Ce6.9–Ba6.4–Lu5.9	Hf3.5–Th3.1	Sc1.8–Fe1.5–Ca1.5–Hg1.2
reinforced concrete plants	U22–As16.8–Tb13.1–Yb12.5–La12.1	Ta9.6–Sm9.1–Ba7.5–Ce6.7–Na5.1	Lu4.6–Hg3.9–Sr3.8–Ca3.1–Sb3.1–Th3	Hf2.6–Co1.9–Fe1.5
Power station	U21.2–Tb13.9–As13.8–Yb13–La11.6	Ta9.5–Sm9.3–Ba7.4–Ce6	Lu4.7–Sr4–Hg3.5–Na3.4–Th3	Sb2.1–Hf1.9–Co1.8–Ca1.7–Fe1.6–Br1.5
Petrochemical plant	U26.2–Tb16.6–Yb16.2–La15.3–Ta13–Sm11.3	As9.7–Ba8.5–Ce8.3–Lu5.9–Hg5.1	Th4.7–Na4.1–Hf3.3–Br3	Sr2.1–Fe1.9–Sb1.6–Cs1.4
Tomsk	U13,8–Tb11,5	Yb9,5–La9–Ba8,6–Ta8,1–As7,6–Sm7,6–Ce5,2	Na4,5–Ag4,3–Br4,2–Lu4,1–Hg4,2–Sb3	Th2,3–Hf2,1–Sr1,8–Ca1,5–Fe1,4–Co1,3–Sc1,2–Eu1,1–Cs1–Cr0,9–Rb0,8–Au0,3

We can find out the plant which is responsible for the higher concentration of some elements in dust aerosols. For example, U, Tb, Yb, La, Ba, Ta, As, Sb, Ce, Na, Ag, Br, Lu, Sb, Hg are the dominant elements in dust aerosols of Tomsk. Tb, As, Na, are the dominant elements in dust aerosols of construction plants.

Factor of pollutant (element) load on the environment is calculated by the snow sampling results. The factor is defined as a pollutant mass falling on a unit of square in a unit of time. Total pollutant mass (P_n, dust burden) and element concentrations (C) in the snow solid residue are used to calculate the factor. Based on that the following factors are calculated.

1. Total load producing by the chemical element emissions in the environment (or average daily fallout of metals on the city territory) is calculated by the formula (3):

$$P_{total} = C \times P_n \text{, mg/km}^2 \text{ per day.} \quad (3)$$

2. Coefficient of relative increase in total elements load is calculated by the formula (4):

$$K_p = P_{total} / P_b , \quad (4)$$

P_b – background value of total element load. It is calculated by the formula (5):

$$P_b = C_b \times P_{nb}, \tag{5}$$

P_{nb} – background value of dust load, it is 10 kg/km^2 per day for the non chernozem zone of Russia.

As the anthropogenic abnormalities usually comprise many elements, total pollution factor (Z_c) and factor of total element load (Z_p) are calculated. It characterizes the impact of the group of elements. The factors are calculated by the formula (6–7):

$$Z_c = \sum KK - (n-1); \tag{6}$$

$$Z_p = \sum K_p - (n-1), \tag{7}$$

n – a number of elements having KK and K_p values more than 1.

There is the following gradation for values of total pollution factor:

- less than 64 – low contamination level; safety morbidity level; lower change of children's health;
- 64–128 – middle contamination level; mildly unsafe morbidity level; increase in total morbidity;
- 128–256 – high contamination level; unsafe morbidity level; increase in total morbidity and number of illness children;
- more than 256 – very high contamination level; immensely unsafe morbidity level; very high level of morbidity, there are many children with chronic diseases and abnormalities in physical abilities.

For example, total pollution factor value ranges from 64 to 128 in Tomsk. It refers to the middle contamination level.

3.2.4. Mineral and anthropogenic particles in the insoluble fraction of aerosols in snow

In addition the material constitution of snow solid residue investigating can be carried out. Modern mineralogical methods of investigation (such as electron microscopy, spectrum microanalysis with laser sampling, panning analysis, X-ray analysis, thermal analysis, impulse cathodic luminescence) are used to study material constitution of snow solid residue.

Mineral and anthropogenic particles can be determined with a help of modern methods according to patent № 2229737 on October, 17, 2002. (Yazikov E.G., Shatilov A. Yu., Talovskaya A.V. The method of determination of snow cover pollution with anthropogenic components). It allows determine areas of anthropogenic particles high concentration and their source.

Microscopic examination of samples is carries out by the binocular stereoscopic microscope. Detailed study of microparticles makes possible to characterize particles with determination of color, luster, hardness, transparency, form, and size of particles, characteristic of surface, degree of roundness and oxidization.

In the samples one determines the percentage of all types of mineral, biogenic and anthropogenic particles by the method of comparison with standard circles of S.A. Vakhromeev template (Вахромеев, 1956) in such a way that content of all particles would make 100 % (fig. 3.2.4.1).

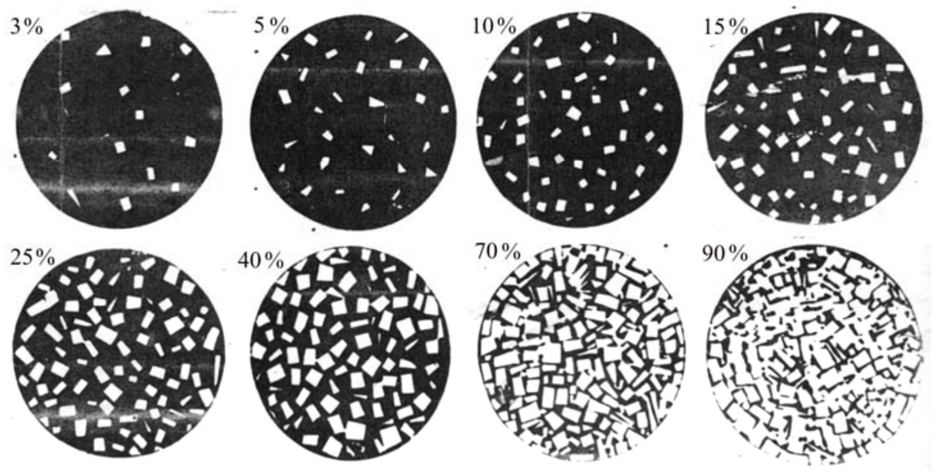


Fig. 3.2.4.1. Comparative method of determination (from S.A. Vakhromeev)

The essence of this method consists in comparison of amount of particles in the sample observed under microscope in some field of view with standard circles, on the black background of which there is a number of white figures. When compared it is not difficult to find the closest in composition standard and in this way state the percentage of each type of particles in the sample.

On the basis of the data one can determine the content and relationship of minerals, biogenic particles, and anthropogenic formations.

This section is made on basis of mineral composition studying of snow solid residue on urban territories of the south of the West Siberia (Шатилов, 2001; Язиков, 2003; 2004; 2006; Таловская, 2008).

According to results of investigation there were mineral and anthropogenic particles in snow solid residue samples.

Mineral and biogenic particles.

1. Transparent colourless particles, gravel and non-gravel present microparticles of quartz structure of the top soil layer (fig. 3.2.4.2). Sizes of particles are from 28 μm to 1 mm. Under electron beam quartz has got high intensity of fluorescence and blue colour.

2. Brown-orange or yellow, semitransparent, partially gravel particles present microparticles of quartz bank sand covered with iron hydroxide and manganese hydroxide (fig. 3.2.4.3). Sizes of particles are from 28 μm to 1 mm.

3. The microparticles of dendro-vegetational origin (fig. 3.2.4.4). Sizes of particles are from 0,1 mm to 0,6 mm.

4. Gravel particles of reddish colour – feldspars (fig. 3.2.4.5). Sizes of particles are from 20 to 500 μm. Under electron beam feldspar has got high intensity of fluorescence and pink colour.

5. Clay particles, mainly kaolin (fig. 3.2.4.6). Sizes of particles are 15 μm.

6. Mica flakes of different colour and tints: colourless, green and golden (fig. 3.2.4.7). Sizes of particles are from 50 to 750 μm.

7. Particles of amphiboles, the special feature of them is rectangular cleavage (fig. 3.2.4.8). Sizes of particles are from 3 to 5 μm.

8. Semigravel particles of carbonate, milky colour (fig. 3.2.4.9). Sizes of particles are from 30 to 550 μm. Under electron beam carbonate has got high intensity of fluorescence and violent yellow colour.

Presence of mineral particles in investigated samples is confirmed by X-ray phase analysis. By way of analysis the quartz, carbonate, feldspar, hematite (goethite) and also clay minerals (illite-montmorillonite, hydrobiotite and trace chlorite) were identified in samples against the background of X-ray phase analysis.

Mineral part of coals burnt in boiler rooms generally consists of aluminosilicates, carbonates and iron sulfides.

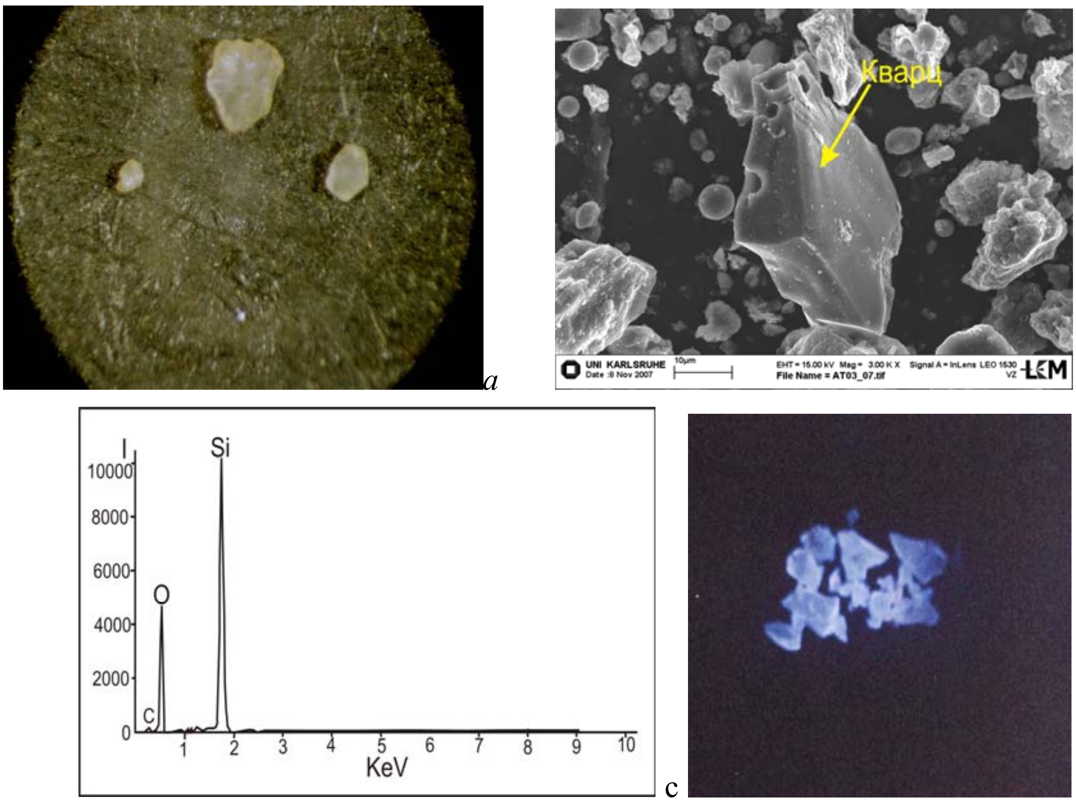


Fig. 3.2.4.2. Particles of quartz (from 28 μm to 1 mm):
a) under a binocular microscope (magnification 50^x);
b) under an electron microscope (magnification 3 K^x); c) energo-dispersive spectrum;
d) results of impulsive cathodic luminescence

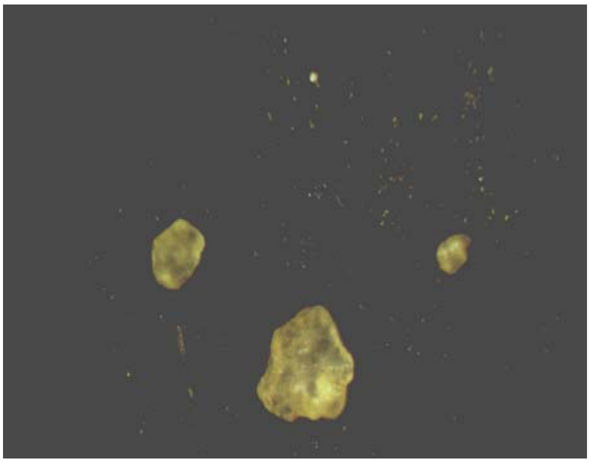


Fig. 3.2.4.3. Particles of quartz covered with oxidized films (from 28 µm to 1 mm) (binocular, magnification 50^x)

Fig. 3.2.4.4. Vegetable particles (0,1…0,6 mm) (binocular, magnification 50^x)

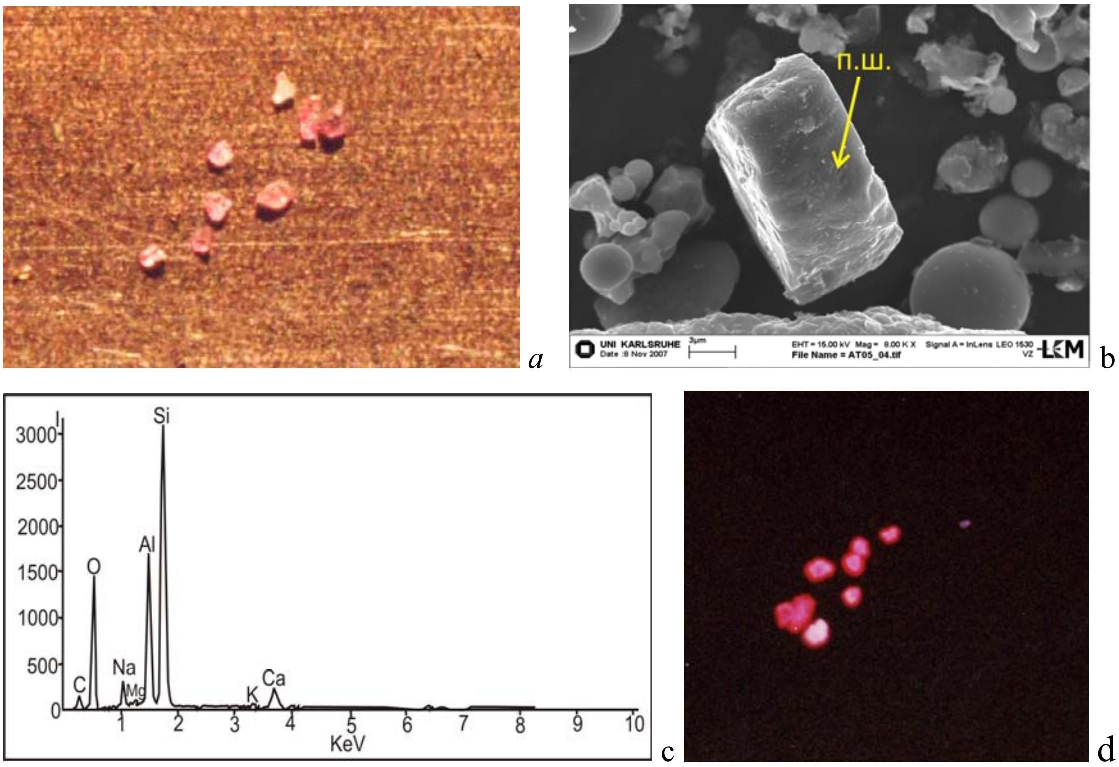
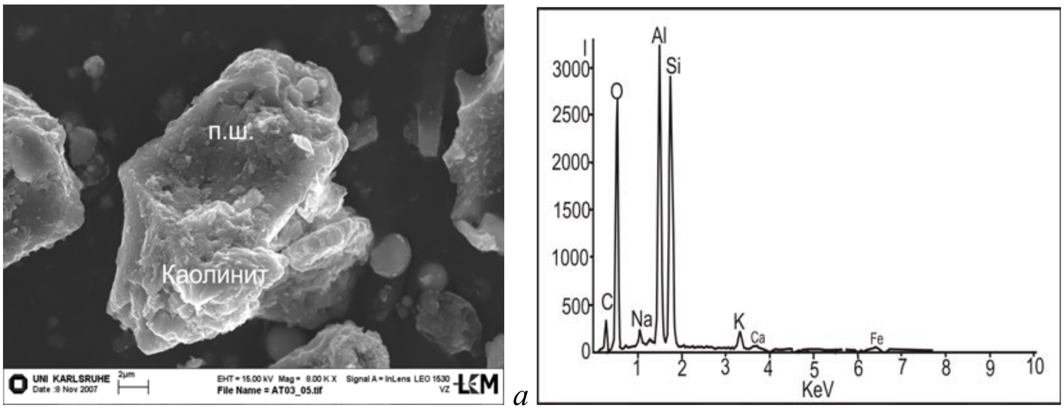
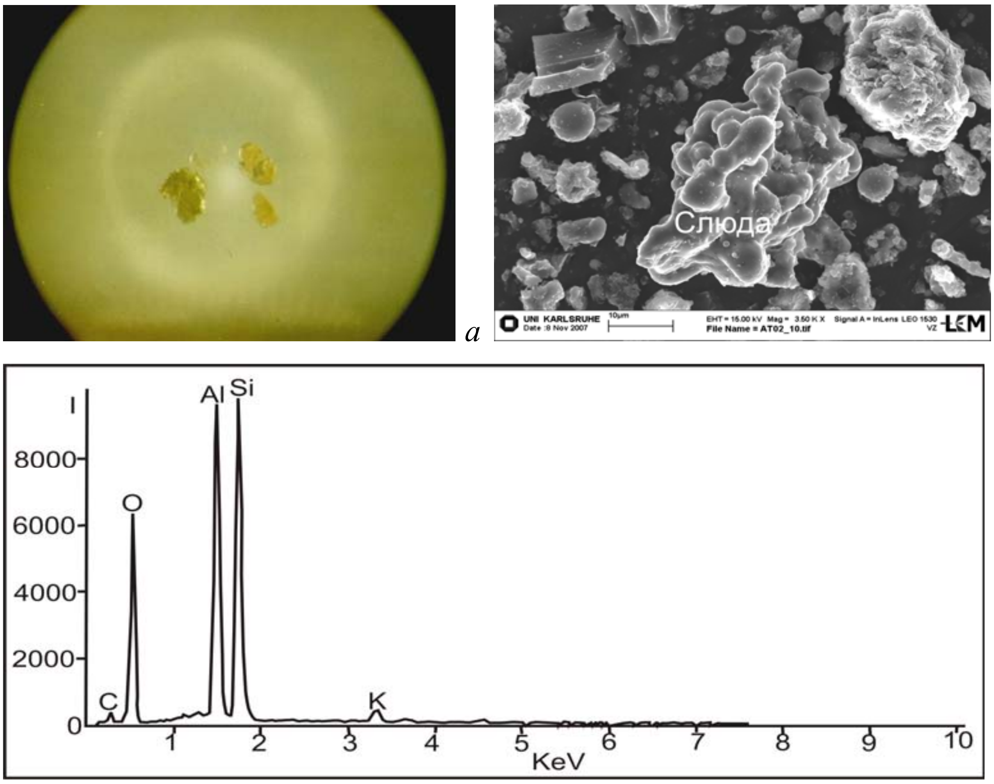


Fig. 3.2.4.5. Particles of feldspar (from 28 µm to 1mm):
a) under a binocular microscope (magnification 50^x);
b) under an electron microscope (magnification 8 K^x); c) energo-dispersive spectrum;
d) results of impulsive cathodic luminescence



a b

Fig. 3.2.4.6. Particles of kaolin and feldspar (from 28 μm to 1 mm):
a) under an electron microscope (magnification 8 K^x);
b) energo-dispersive spectrum

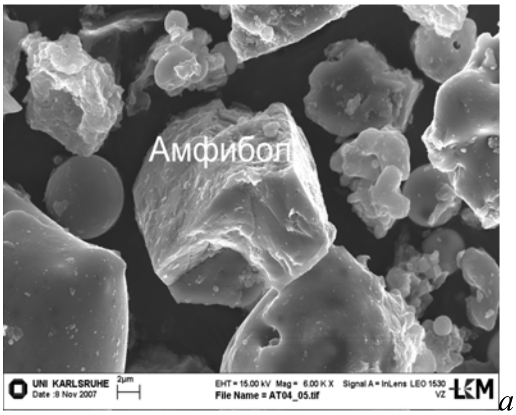


a b c

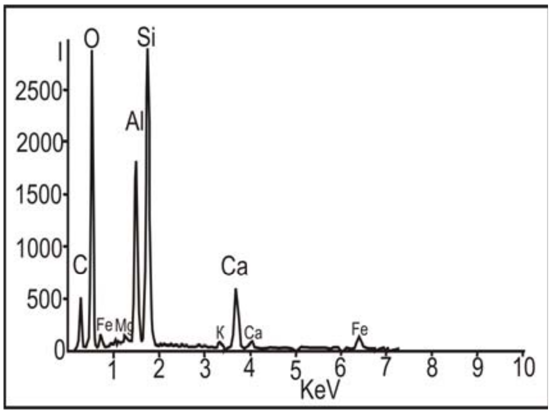
Fig. 3.2.4.7. Particles of mica (50…750 μm):
a) under a binocular microscope (magnification 50^x);
b) under an electron microscope (magnification 3,5 K^x); c) energo-dispersive spectrum

According to X-ray structure analysis this fact explains that in samples of snow solid residue there is presence of amorphous quartz (glass phase), cristobalite and mullite forming at high-temperature processes of the combustion chamber of boiler rooms. Iron oxides can pass to environment both with emissions of fuel-energy complex and metal-working plants. Erosion of banks, emissions of building industry plants, anti-ground surface icing actions and also long-range air-mass transport from Central Asia are the natural minerals source.

Electrical power engineering (27 %), nonferrous metallurgy (22,5 %) and ferrous metallurgy (15,8 %), petroleum production (9%) and oil refining (5,1 %), enterprises for oil extraction and refinement (15,5 %), transport (13,1 %), coal industry, gas industry, mechanical engineering and also enterprises for extraction and manufacture of building materials are the basic sources of anthropogenic atmospheric pollution connected with human activity (Экологический ….., 2002).



a



b

Fig. 3.2.4.8. Particles of amphiboles (3…5 μm):
a) under an electron microscope (magnification 6 K^x); b) energo-dispersive spectrum


a


b

Fig. 3.2.4.9. Particles of carbonate (30…550 μm):
a) under a binocular microscope (magnification 50^x);
b) results of impulsive cathodic luminescence

The following types of ***anthropogenic particles*** were found out in examined samples:

1. Light-grey and white microspherules with vitreous luster and hollow inside (fig. 3.2.4.10). Sizes of particles are from 14 μm to 280 μm.

Fig. 3.2.4.10. Microspherules of silica-alumina composition (binocular, magnification 50ˣ)

There are two hypotheses of silica-alumina hollow microspherules (SAHM) – anthropogenic hypothesis and cosmic hypothesis. Anthropogenic hypothesis was proved by way of example ash of pulverized coal firing (Кизильштейн, 1987; 2002). These silica-alumina hollow microspherules are one of the components of ash loss of heat coal-fired power stations. Accor-ding to results it was discovered that SAHM consist of mullite and sillimanite. In addition the chemical analysis showed that they are mainly enriched by Al_2O_3 and Fe_2O_3, CaO, SO_3 a little. Cosmic hypothesis was examined by the way of example nizhnepermskikh saline deposits.

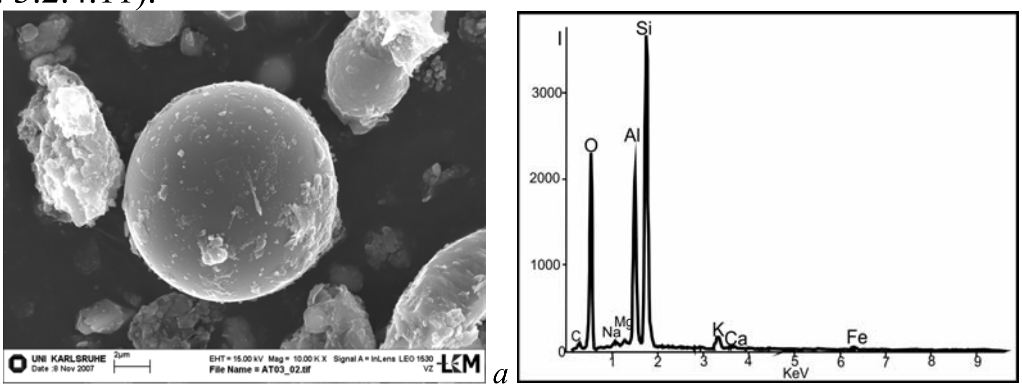
Several spherical fritted formations of silicate and mixed composition were found in nizhnepermsky age mine salt washed out the surface of salt deposit (Ivanov, 1968).

The investigations of snow solid residue of Tomsk district Tomsk oblast' showed that these white microspherules consist of mullite (Язиков, 2006).

Abundance of these particles in snow solid residue shows that they are emissions of heat boiler rooms and electric power stations using coal in their process technology.

Two types of microspherules distinguished by their morphology were revealed according to results of detailed electron microscopic investigations.

Smooth spherules are formed at high-temperature process and they are emitted into atmosphere. They mainly include Al and Si in their composition; they are often called "combustion spheres" (Аэрозоли …, 2006) (fig. 3.2.4.11).



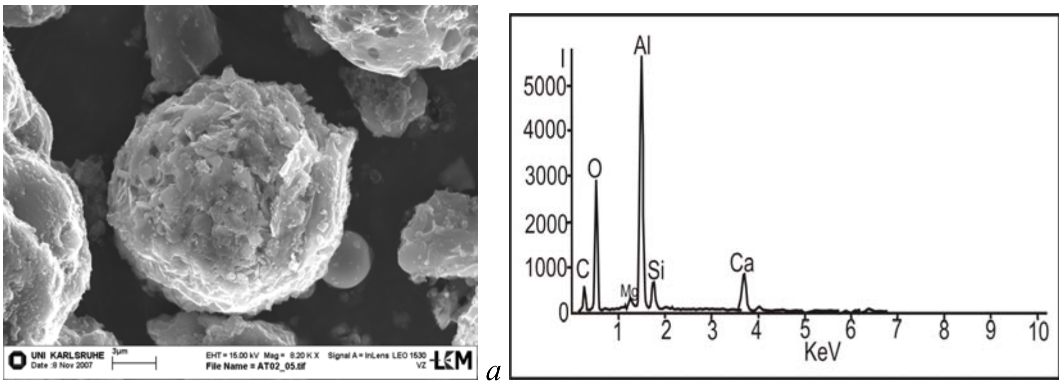
a b

Fig. 3.2.4.11. Smooth Al-Si- microspherules (0,5…12 µm):
a) under an electron microscope (magnification 10 Kˣ); b) energo-dispersive spectrum

They can transport by air mass for long distances. They were discovered in the Arctic aerosols by scientists (Sheredan, 1985; Аэрозоли …, 2006). Diameter of these spherules changed from 0,5 to 12 µm. They are enriched by Al, Si, K and other macroelements.

Presence of microspherules consisting of mullite mainly (as the spectrum of elements is in line with the spectrum of mullite) is characteristic of snow solid residue (Reed, 2005) (fig. 3.2.4.12). Diameter of microspherules changed from 1 to 2 µm. According to results of X-ray structural analysis there is mullite in samples of snow solid residue.

Porous particles of fly ashes containing Al and Si mainly were found in samples. The size of them was from 5 to 45 µm. Spectrum of the chemical element content in these particles is analogous to the spectrum of smooth spherules (fig. 2.2.13). Porous particles of fly ashes pass to atmosphere with emissions of heat electric power stations (Аэрозоли…, 2006).



a b

Fig. 3.2.4.12. Microspherules with mullite (1…2 µm):
a) under an electron microscope (magnification 8,2 K^x); b) energo-dispersive spectrum

2. Black microspherules with metallic luster (metallic microspherules) (fig. 3.2.4.14). Magnetic properties are representative of these particles. Sizes of particles are from 14 to 420 µm.

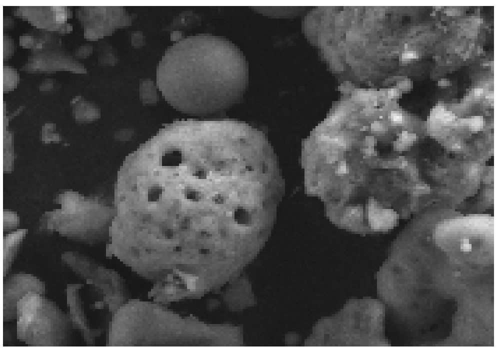


Fig. 3.2.4.13. Porous particles of fly ashes (5…45 µm, electron microscope, magnification 2 K^x, resolution 10 µm)

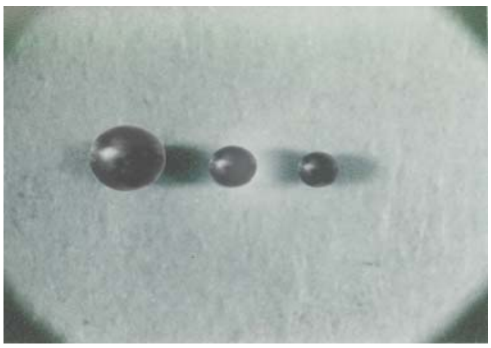


Fig. 3.2.4.14. Metallic microspherules (14…420 µm, binocular, magnification 50^x)

For the first time these spherical particles were discovered by Murray in the late 19-th century (Murray, 1876). Firstly they were found in bottom silt of the Pacific Ocean and later they were found in different natural formations: in Antarctic ice (Schmidt, 1963; Виленский, 1972), bottom ocean silts (Hunter et al., 1960; Parkin et al., 1968), atmospheric dust (Виленский, 1966), saline deposits (Match, 1966; Иванов et al., 1969), peat (Выпадение…, 1975; Бояркина et al., 1976). Under conditions of sedimentation the composition of particles allows to suggest at the very beginning of the investigation that they are cosmic particles. However, later similar spherules were discovered in great numbers in volcanic outburst (Hadge et al., 1964) and industrial emissions (Hoppe et al., 1954; К оценке…, 1973; Буштуева, 1976). They appear also to be formed by huge blast (Keidl, 1969) and because of other types of human activity.

Microbeads containing magnetite, maghemite and hematite were discovered in fly ash of pulverized coal firing at thermal power station (Кизильштейн et al., 1991).

Carried out detailed investigations of single metal microspherules isolated from samples of snow solid residue situated on the mechanical engineering and metal working area and where the casting houses are operating show that they are waste of their production and they present magnesioferrite (Язиков et al., 2003; Язиков, 2006).

Abundance of metal microspherules in samples of snow solid residue shows that they are anthropogenic. According to results of detailed investigations of these particles with a help of laser microspectral analysis it was discovered that Fe, Ti, Au, Ca are prevalent in their composition. Based on the results of detailed electron microscopic investigations 3 types of microspherules were discovered. They contained Fe, Mn and Mg oxides, differed their morphology and had the size from 2 to 20 μm (fig. 3.2.4.15–3.2.4.17).

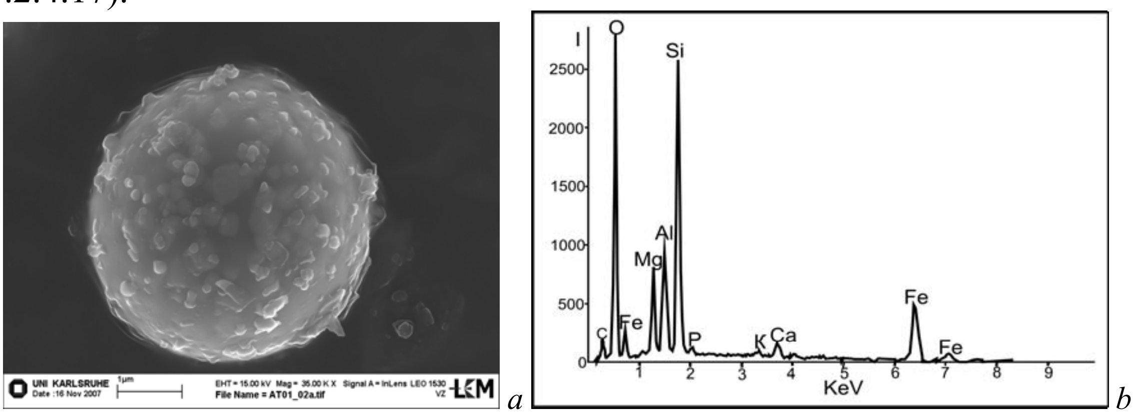


Fig. 3.2.4.15. Microspherules containing Fe and Mg oxides (2…6 μm):
a) under an electron microscope (magnification 35 K^x); b) energo-dispersive spectrum

Metalworking plants and emissions of fuel-and-energy company are the source of these particles entry on the territory of Tomsk and its suburb.

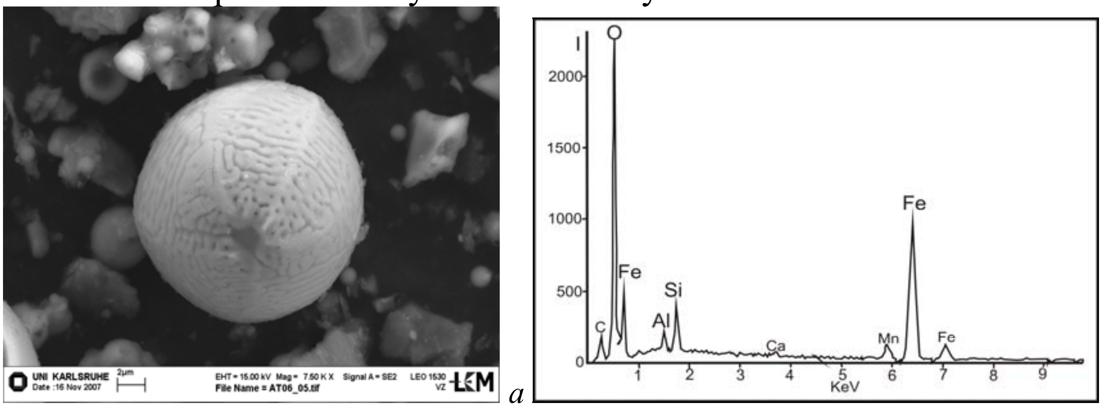


Fig. 3.2.4.16. Microspherules containing Fe and Mn oxides (20 µm):
a) under an electron microscope (magnification 7,5 K^x); b) energo-dispersive spectrum

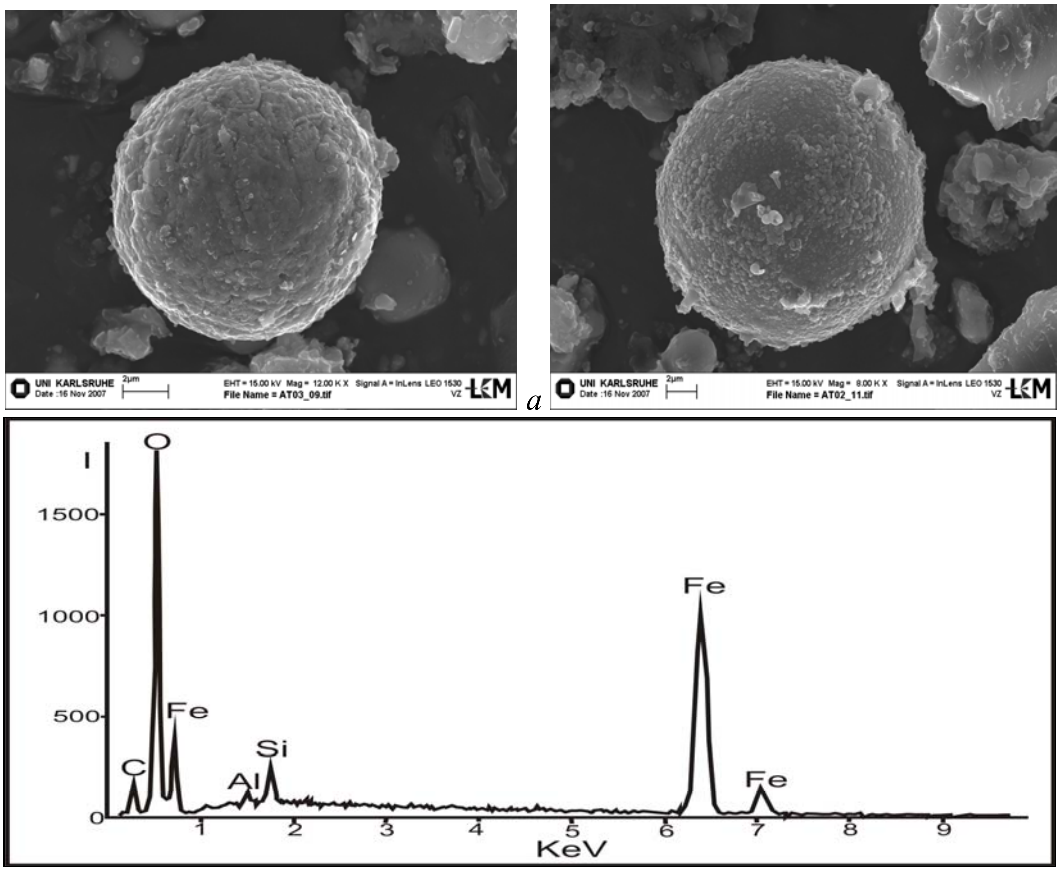


Fig. 3.2.4.17. Microspherules containing Fe oxides (20 µm),
results of electron microscopy:
a) sanitary protection zone of Tomsk GRES-2 OJSC "Tomskenergo"(magnification 12K^x);
b) village Timiryazevo, Tomsk district (magnification 8 K^x); c) energo-dispersive spectrum

Owing to characteristics of atmospheric mass circulation these particles precipitate on the area of villages located out of Tomsk. According to the results of X-ray structural analysis the content of minerals of Fe oxide was detected in samples of snow solid residue. This entitles us to suppose that these minerals present in these microspherules.

3. Non-transparent black flatten form particles are particles of soot and coal (fig. 3.2.4.18). They are typical emissions of heat boiler rooms when burning rubbish. They mainly contain carbon. They have electromagnetic properties. Sizes of particles change from 4 to 40 µm. They present in all samples.

4. Black or brown with submetallic luster formless particles are particles of slag and ash (fig. 3.2.4.19).

According to results of electron microscopy the porous structure or shapeless mass are typical of these particles. These particles contain Al, Si, Ca, Na, Fe etc. Sizes of these particles are from parts per hundred to 720 µm. Particles of slag pass to environment as a result of emissions of heat boiler rooms using coal.

According to results of the investigation of shapeless brown particles with a help of laser microspectral analysis it was discovered that content of Fe, Ti, Cu, Al mainly present in them. These particles present slag containing mostly Fe oxides.

5. Particles of woodwork. They present sawdust and their sizes are from 140 µm to 1 mm (fig. 3.2.4.20).

6. Particles of crushed brick. Their sizes are from 0,2 to 0,6 µm (fig. 3.2.4.21). These particles prevail in samples of sanitary-protection zones of brick production plants.

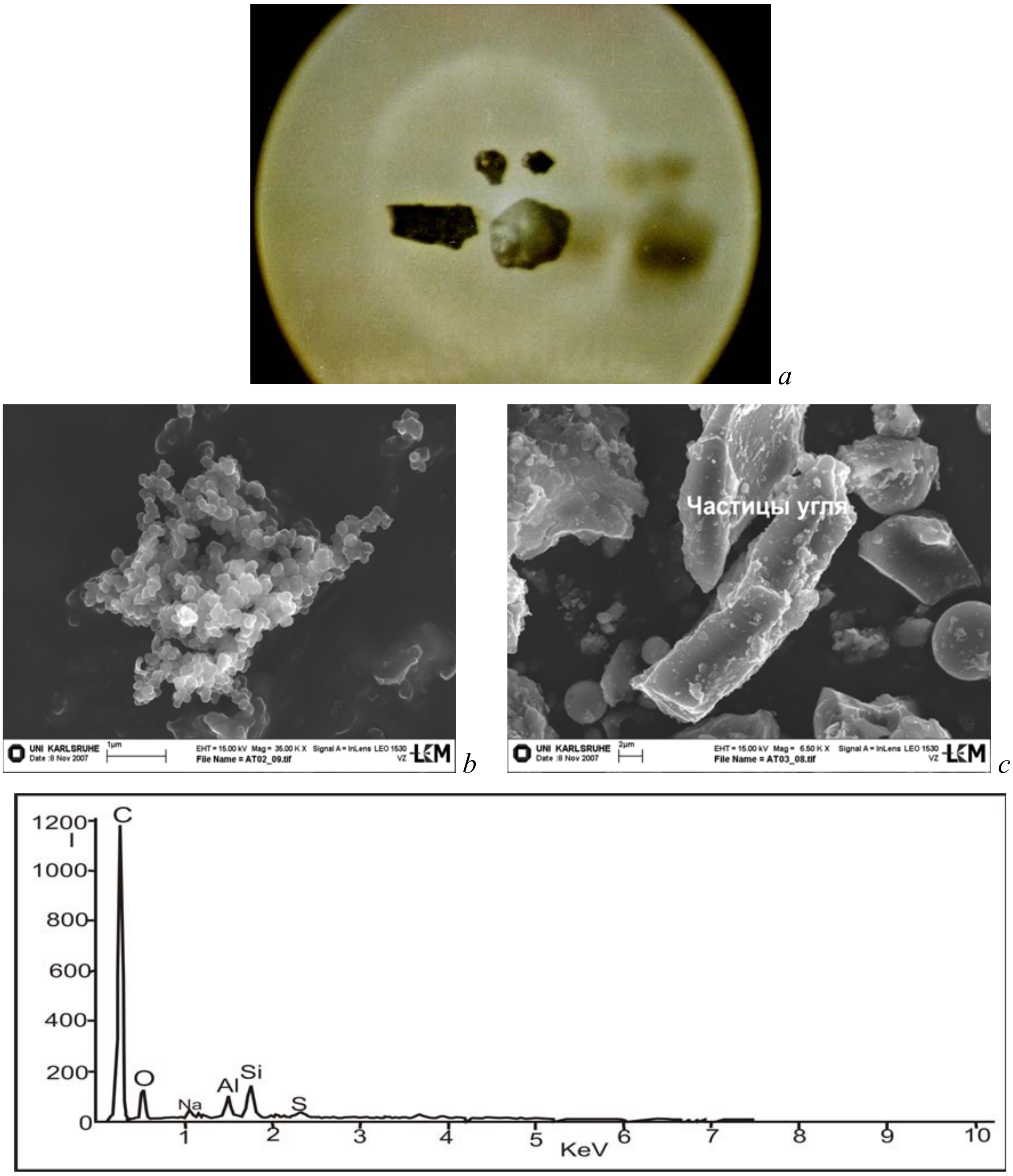
7. Fibrous particles. Their sizes are from 1 to 2 mm.

8. Saccharide particles covered with white thin coat. Their size ranges from 50 to 100 µm.

9. Brown microspherules with glassy luster. Their size ranges from parts per hundred to tenth µm.

10. Black conchoidal particles of duff dust (fig. 3.2.4.22). They are widely distributed in snow samples of the coalmining area. Particles get snow cover both from surface coal mines and enriching factories. According to data of the laser microspectral analysis in the composition of particles there are C, Fe, Ca having weak electromagnetic properties. Their size changes from 28 µm to 1 mm.

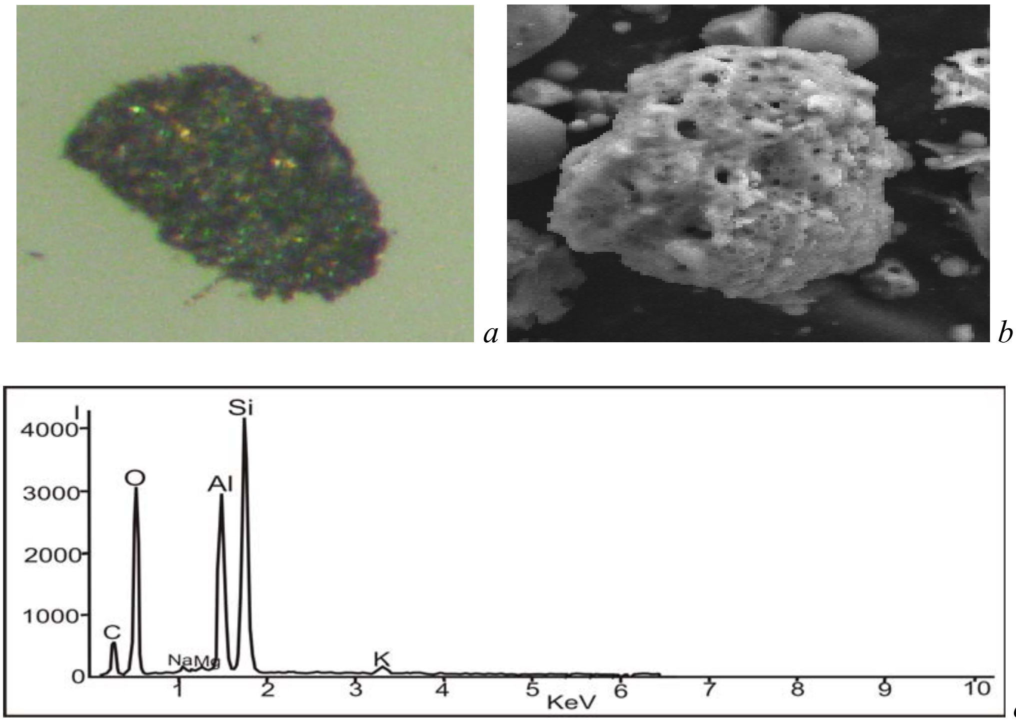
11. Brown shapeless small metal particles (fig. 3.2.4.23). According to data of the laser microspectral analysis these particles contain Mn, Mg, Al, Ti, Cu, Ca, Cd. Magnetic properties are typical of them. Grey iron foundry is a basic source. They are in samples of mechanical engineering and metal working areas. Size of particles is from 14 to 520 µm.



a *b* *c* *d*

Fig. 3.2.4.18. Particles of soot and coal (4…40 μm):
a) under binocular microscope (magnification 50^x); b)particles of soot under an electron microscope (magnification 35 K^x); c) particles of coal under electron microscope (magnification 6,5 K^x); d) energo-dispersive spectrum

12. Orange angular particles present particles for plastic manufacturing (fig. 3.2.4.24). They have weak electromagnetic properties. Size of particles changes from 14 to 280 μm. These particles present in samples of snow solid residue of Tomsk OJSC "Sibelectromotor" area.



a *b* *c*

Fig. 3.2.4.19. Particles of slag (14…720 µm): a) under binocular microscope (magnification 50ˣ); b) particles of slag under an electron microscope (magnification 1 Kˣ, resolution 20µm); c) energodispersible spectrum

Fig. 3.2.4.20. Woodwork particles (from 140 µm to1mm) (binocular, magnification 50ˣ)

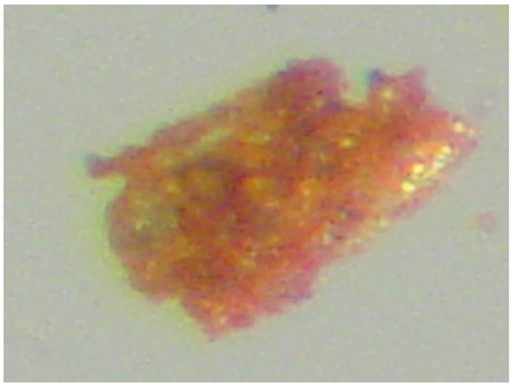


Fig. 3.2.4.21. Crushed brick (0,2…0,6 µm) (binocular, magnification 50ˣ)

13. Grey semiangular silicate spherules (fig. 3.2.4.25). They have weak electromagnetic properties. According to laser microspectral analysis these particles contain Si, Fe, Mn, Mg, Al, Ca, Cd in their composition. These particles are typical of emissions of iron foundry. Size of particles changes from 14 to 520 µm.

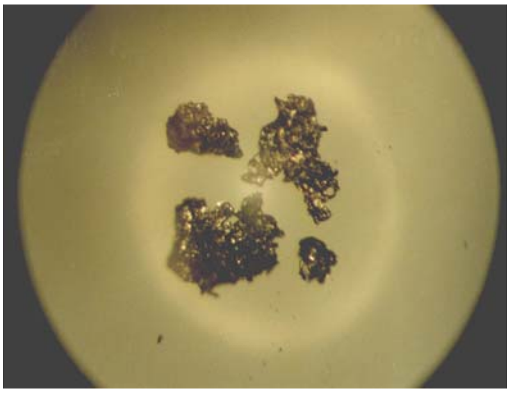


Fig. 3.2.4.22. Black conchoidal particles (duff dust, from 28 µm to1 mm) (binocular, magnification 50ˣ)

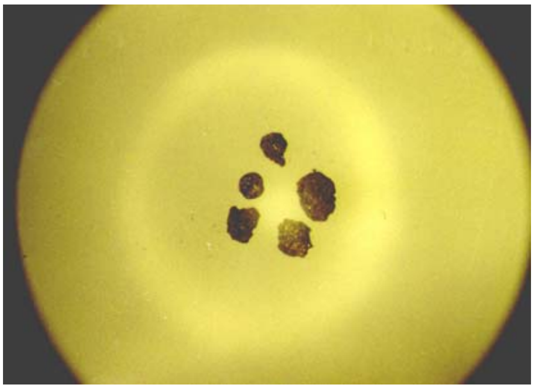


Fig. 3.2.4.23. Brown shapeless metal particles (waste of metal-working, 45…520 µm) (binocular, magnification 50ˣ)

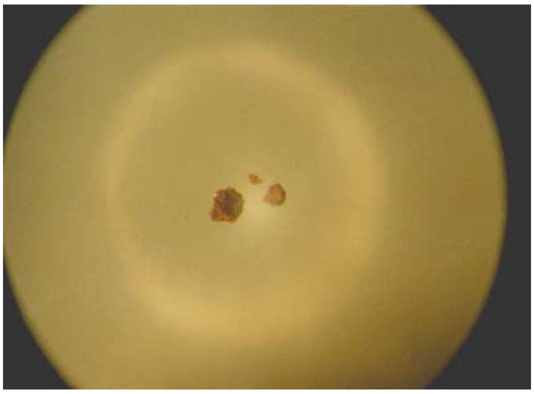


Fig. 3.2.4.24. Orange angular particles (14…280 µm) (binocular, magnification 50ˣ)

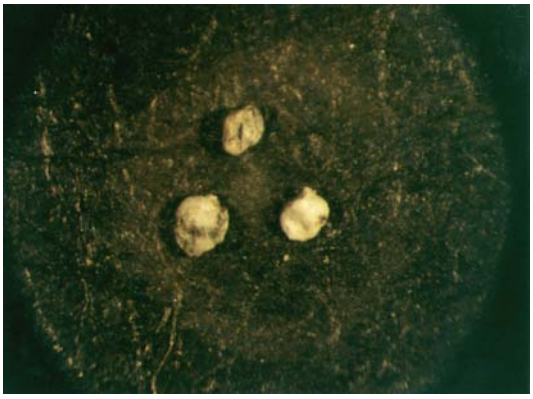


Fig. 3.2.4.25. Grey semirounded particles (14…520 µm) (binocular, magnification 50ˣ)

In baseline regions the natural constituent of dust aerosol fallings in snow cover is upon the average 70 % for Vasyuganskoe swamp though the anthropogenic component represents microparticles of soot (90 %). Jet fires of oil fields in the Ob high-water bed are the most probable source of soot (fig. 3.2.4.26–3.2.4.27). Whereas samples took 70 km away from SW of Tomsk on the territory of wildlife reserve "Tomsky" have 80 % (natural) to 20% (anthropogenic) ratio and also specific mineral composition.

Natural origin microparticles are base of aerosol fallings in oil-and-gas producing area with low urbanization at lower course of the river Ob' on the territory of towns such as Strezhevoy, Megion and Kedrovy. The source of anthropogenic origin particles (soot, metal and non-metal microspherules) is probably a private sector, small industrial enterprises and also numerous jet fires of oil fields (fig. 3.2.4.28).

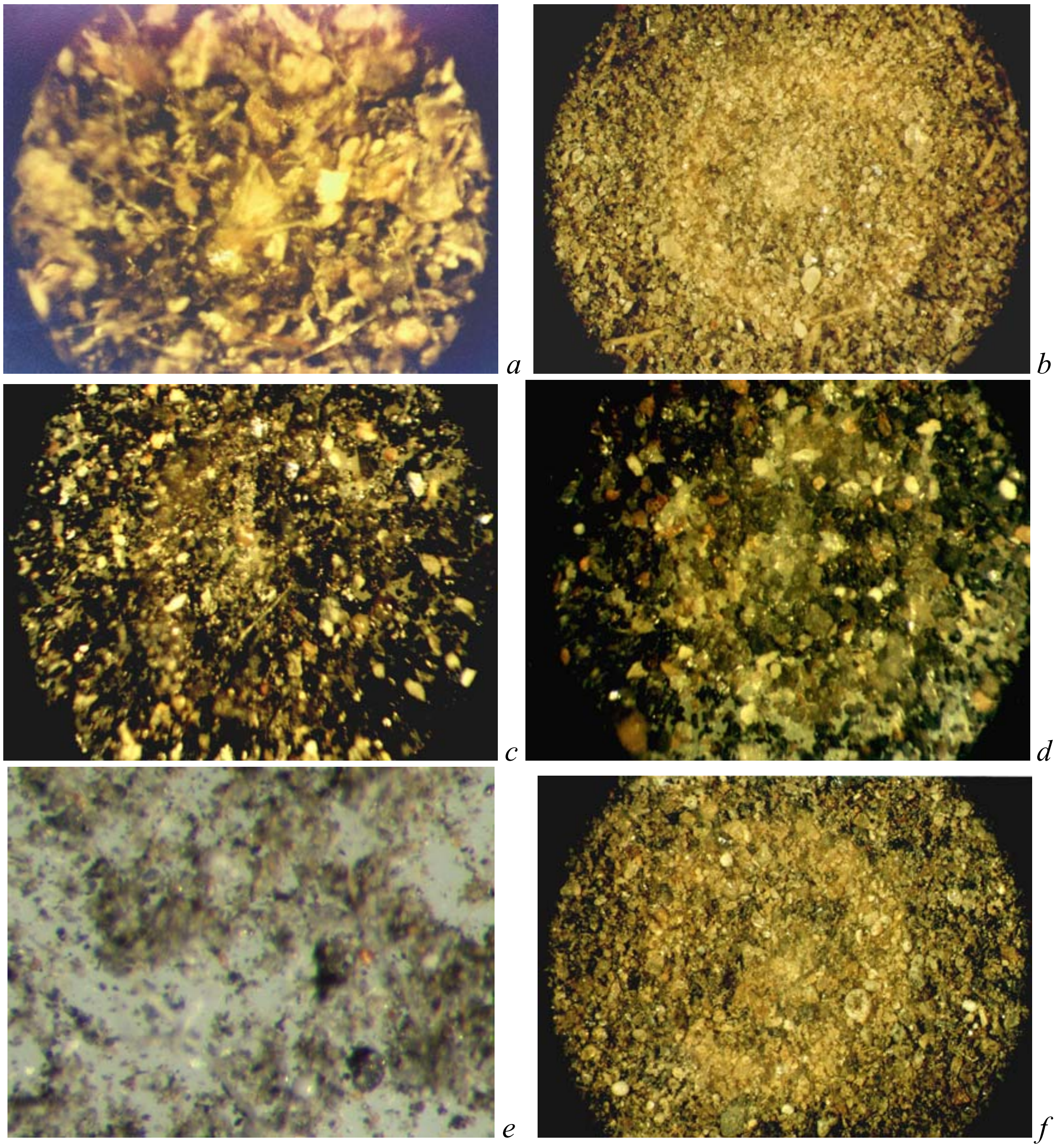
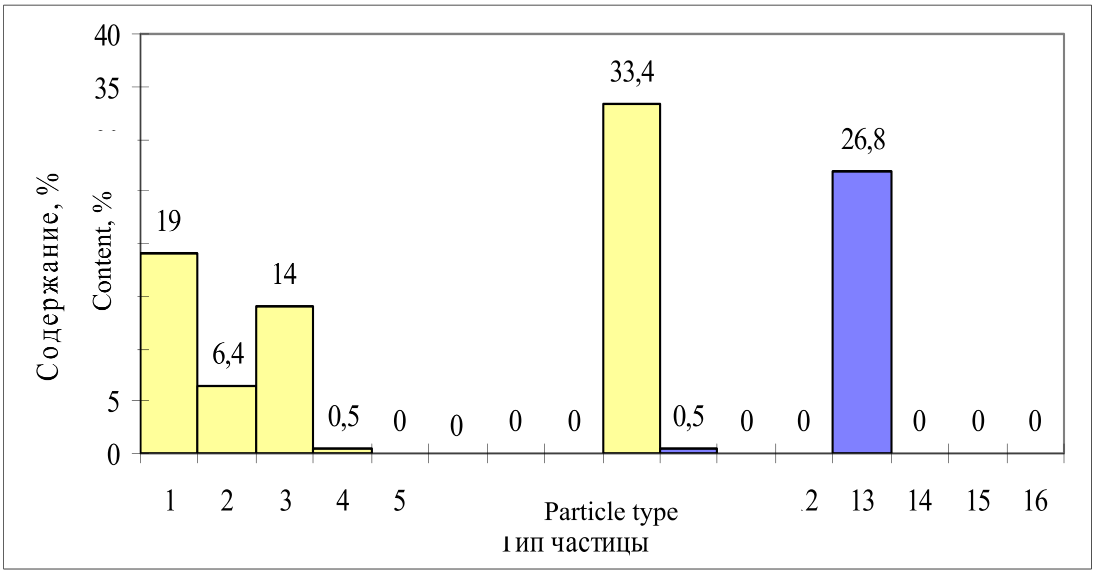
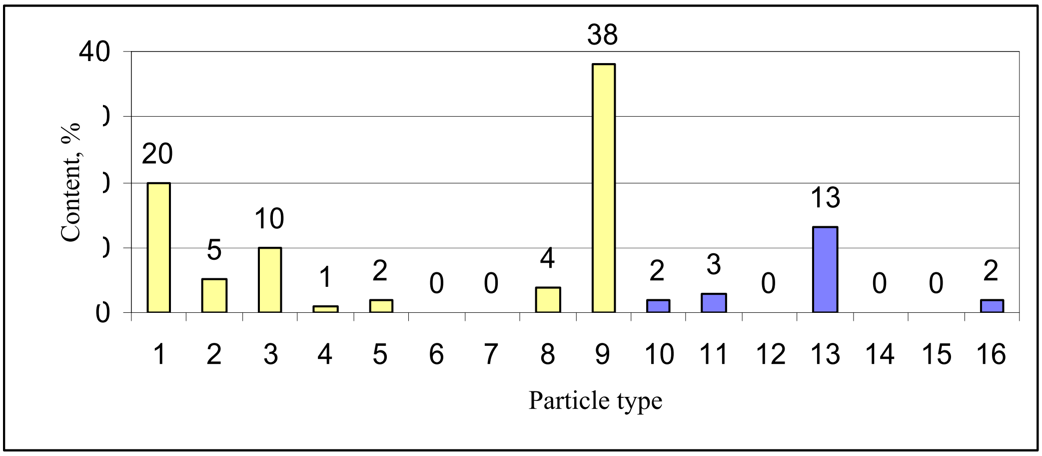


Fig. 3.2.4.26. General view of snow cover solid residue under binocular microscope (magnification 70^x):
a)area of regional background of West Siberian region;
b) oil-and-gas producing area; c) coal mining area;
d) mechanical engineering and metal working area;
e) territory of Tomsk (magnification 50^x);
f) the territory of industrial plant OJSC "Sibelectromotor" (Tomsk)

Particles of duff dust prevail in samples of coal mining area of Kuzbas (at upper river of the Tom') where the town Mezhdurechensk is situated. It is connected with activity of the numerous surface coal mines situated around the town (fig. 3.2.4.29). Under the microscope these samples are black and look like duff dust.



a



b

Fig. 3.2.4.27. Mineral composition of snow solid residue:
a) regional background of West Siberian region;
b) local background of West Siberian region

Mineral components (1–9): *1 – transparent colourless particles, non-gravel (quartz); 2 – semitransparent yellowish particles, gravel (quartz); 3 – quartz grains with films and inclusions of Fe hydroxides; 4 –brown irregular shape particles (Fe hydroxides); 5 – white particles (carbonate); 7 – yellow angular particles; 8 – reddish-brown particles(feldspar); 9 – wood-vegetable origin particles.* ***Anthropogenic components (10–17):*** *10 – metal microspherules (magnesioferrite); 11 – aluminosilicate microspherules (mullite); 12 – black conchoidal particles (duff dust); 13 – particles of soot; 14 –brown shapeless metal particles (waste of metal-working); 15 – orange particles; 16 – grey semirounded particles; 17 – particles of paint.*

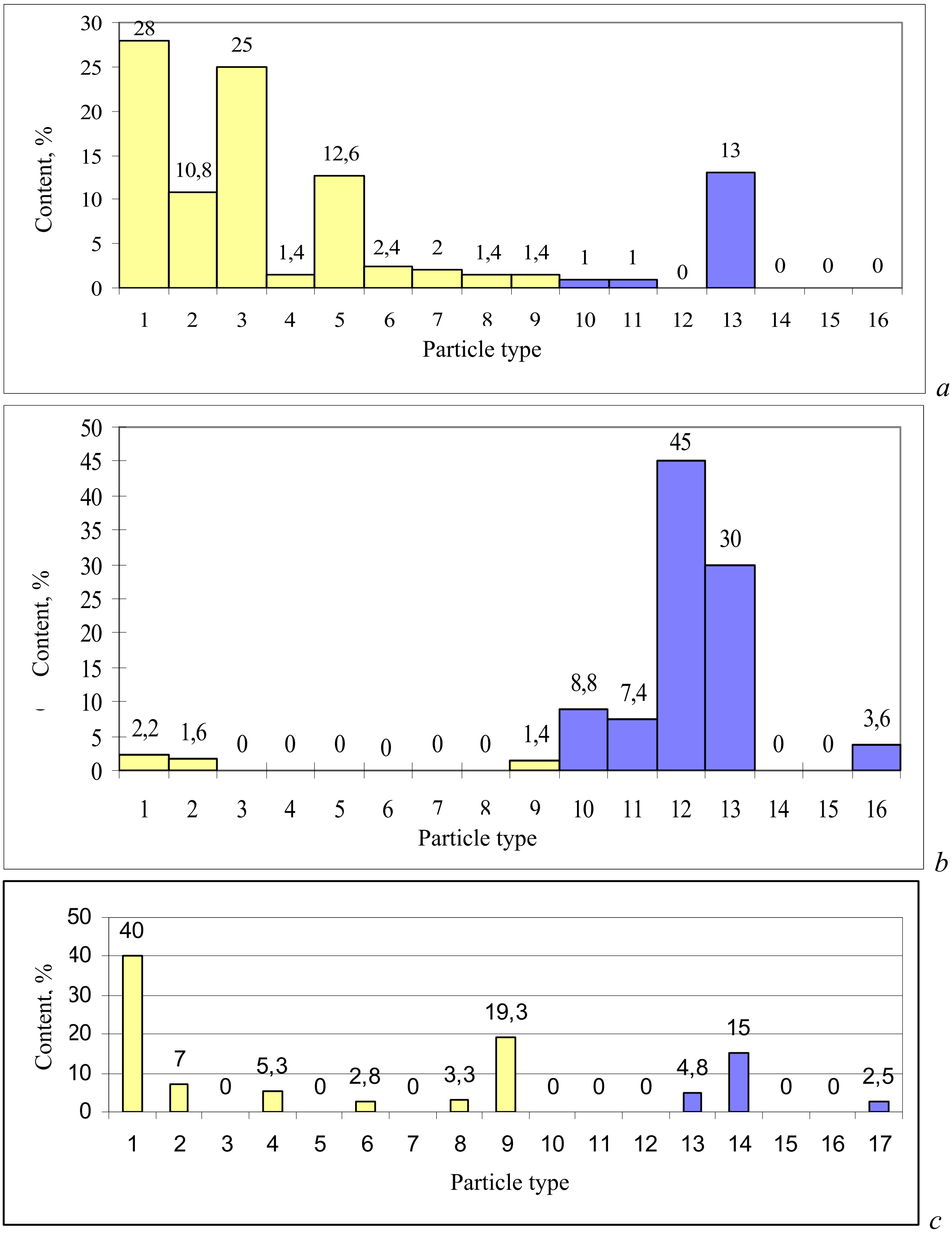
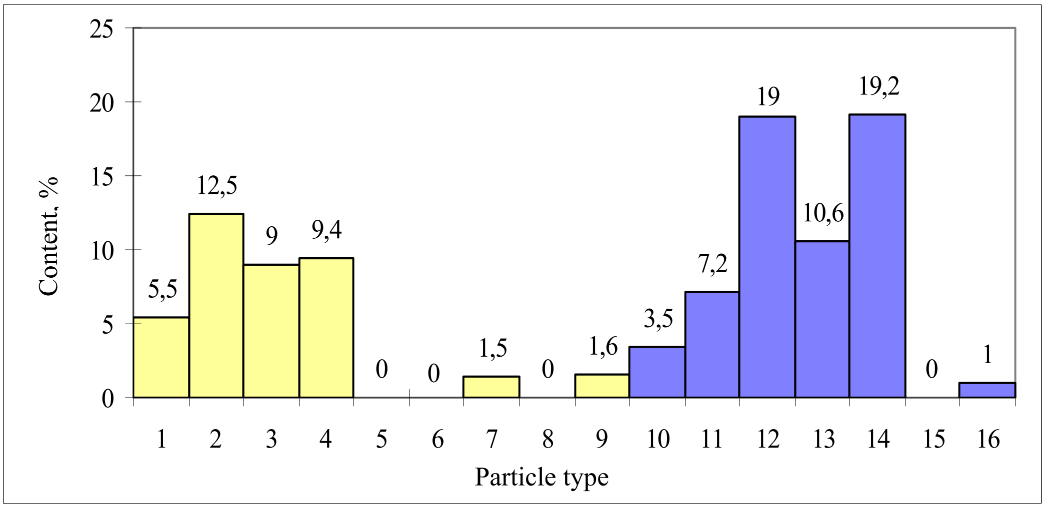


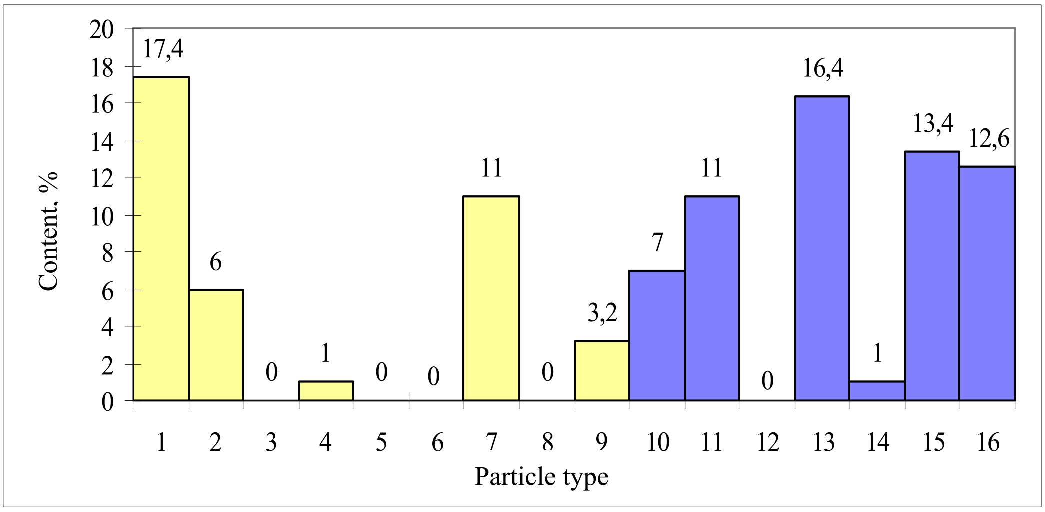
Fig.3.2.4.28. Mineral composition of snow solid residue:
a) oil-and-gas producing area; b) coal mining area;
c) iron ore mining area (notations 1–17 fig. 3.2.4.27)

Particles of bearing strata prevail in samples of snow cover solid residue in ore mining area of Khakasiya (at upper stream of the Vershina Tei) where the similarly-named settlement of mineworkers is situated and where iron ore deposit excavate. It is connected with mining firing in open cast mine and its dump pit (fig. 3.2.4.28).

The composition of aerosol fallings depend on specific character of industrial production and their local sources of pollution. Thus, microparticles of metallurgical slag and metal-working prevail in snow samples of solid residue on the territory of mechanical engineering and metal-working area (OJSC "Rubtsovsky plant, Altaisky region) (fig. 3.2.4.29).



a



b

Fig. 3.2.4.29. Mineral composition of snow solid residue:
a) mechanical engineering and metal-working area;
b) territories of OJSC "Sibelectromotor"(Tomsk)
(notations 1–16 fig. 3.2.4.27)

The similar composition of snow solid residue is on the territory of OJSC "Sibelectromotor"(Tomsk) where particles of metallurgical slag, waste of sandy jet metal-working and production of plastic prevail (fig. 3.2.4.29).

The portion of anthropogenic and natural origin particles in snow solid residue on the territory of Tomsk changes from 10 to 40 % and from 60 to 90 % appropriately. The high level of anthropogenic environmental load on the territory of Tomsk is due to different industrial plants (fig. 3.2.4.30).

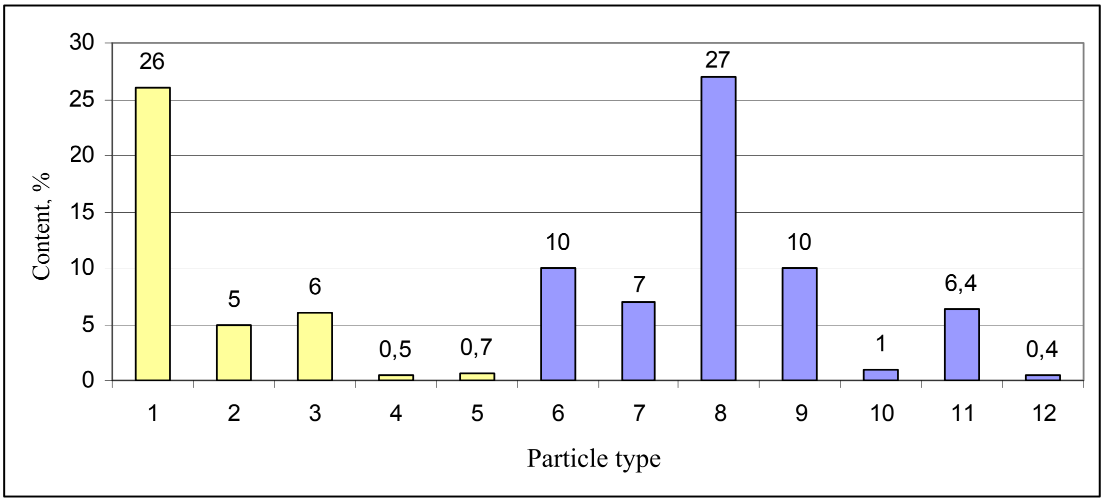


Fig. 3.2.4.30. Mineral composition of snow solid residue on the territory of Tomsk: ***Natural mineral components (1–5):*** *1 – transparent colourless particles, non-gravel (quartz); 2 – quartz grains with films and inclusions of iron hydroxides; 3 – wood-vegetable origin particles; 4 –reddish-brown particles (feldspar); 5 – particles of mica.* ***Anthropogenic components (6–12):*** *6 – aluminosilicate microspherules (mullite); 7 – metal microspherules (magnesioferrite); 8 – particles of soot and coal; 9 – particles of slag and ash; 10 – fibrous particles; 11 – crushed brick; 12 – particles of paint*

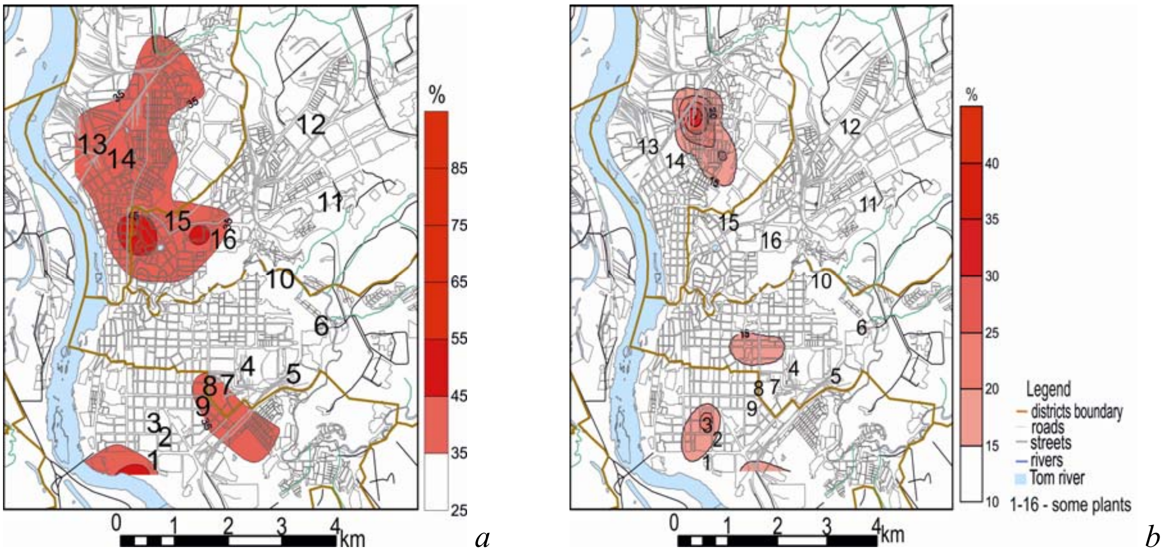


Fig. 3.2.4.31. Distribution of soot and coal (a),slag (b) in dust aerosols on the territory of Tomsk according to snow survey: industrial plants (1–16): 1 – LLC "Kontinent"; 2 – OJSC "Tomsky instrument"; 3 – OJSC " Tomsky electrolamp plant"; 4 – Tomskaya GRES-2 OJSC "Tomskenergo"; 5 – LLC "Plant of concrete panel construction TIHBF"; 6 – LLC "Plant "Emalprovod"; 7 – OJSC "Manotom"; 8 – OJSC "Sibelectromotor"; 9 – FSUE " Tomsk elecrotechnical plant" and SPA "Polus"; 10 – ash disposal area of Tomskaya GRES-2; 11 – CJSC "Karieroupravlenie "; 12 – OJSC "Concrete plant -100" and LLC "Keramzi-T"; 13 – Tomsk treating plant OJSC "Transwoodservice"; 14 – LLC "Tomsk plant of rubber footwear"; 15 – CJSC "Sibkabel"; 16 – CJSC "Tomsky bearing"

The natural component of dust and aerosols in winter is mainly presented by particles of quartz and plant residues (10…40 %) coming in consequence of the river Tom' wind erosion and due to sanding roads when it is ice-slick. The principal part of anthropogenic material is particles of soot and coal (20…50 %), slag and ash (15…25 %), aluminosilicate microspherules (5…15 %) passing in environment mainly with emissions of fuel-energy complex.

The high content of slag, soot and coal particles (25…30 %) is accounted for by uptown in impact area of Tomsk GRES-2 and also in the area of private sector – in the northern part of Tomsk (fig. 3.2.4.31).

Thus, mineral composition of dust aerosol fallings on the urbanized territories with diversified anthropogenic load is differed by proportion of natural and anthropogenic origin particles and also it is determined by specificity of local pollution sources.

Revision

Review the questions:

1. What types of the snow geochemical survey are used for snow contamination monitoring?
2. Characterize method of pit used for snow sampling.
3. How snow sample preparation is performed?
4. Enumerate the main components analyzed in snow cover.
5. What types of mineral components does the insoluble fraction of the aerosols in snow consist of?
6. What types of anthropogenic components does the insoluble fraction of the aerosols in snow consist of?

Answer the following questions:

1. What methods use to carry out snow sampling:

a) core method full out of snow cover;
b) pit method full out of snow cover, except 5 cm layer over soil;
c) depth method full out of snow cover, except 5 cm layer over soil;
d) with a help of a snow sorter, except 5 cm layer over soil.

2. Match the factor with its formula:

1) Coefficient of relative increase in total elements load:	a) $P_n = P_o / S \times t$;
2) average daily fallout of metals:	b) $KK = C / C_b$;
3) total pollution factor:	c) $P_{total} = C \times P_n$;
4) coefficient concentration:	d) $K_p = P_{total} / P_b$;
5) factor of total element load:	e) $Z_c = \sum KK - (n-1)$;
6) dust load:	f) $Z_p = \sum K_p - (n-1)$.

3. Match values and the contamination level determined according to dust load value:

1) less than 250 mg/m^2·day: a) high contamination level;
2) 450–850 mg/m^2·day: b) very high contamination one;
3) more than 850 mg/m^2 day: c) middle contamination one;
4) 250–450 mg/m^2·day: d) low contamination one.

3.3. Soil pollution monitoring

3.3.1. Soil pollution

Soils are the natural media in which plants grow. The existence of human, animal, and plant life is dependent upon them. Soils can be found most everywhere and have seemingly always been with us. Soil pollution is contamination of soil with ingredients which can accumulate in the soil or can be mobile and thus can be leached through the soil profile, resulting in contamination of groundwater. These ingredients are often undesirable to the growth and production of plants and may cause health risk to animals and humans if the contaminants are carried through the food chain.

The soil pollutants which affect agricultural production and human habitat are: (a) heavy metals, (b) agri-chemicals, (c) radioactive materials, and (d) petroleum products.

Heavy metals may be applied to the soil with pesticides, as plant nutrients, atmospheric fallout, and as a constituent of waste products. Heavy metals which tend to accumulate in soils include cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), and zinc (Zn).

Table 3.3.1.1

Mean of some total trace elements in soils in Western Europe, in comparison with the contents of US, Canadian and world soils (mg/kg) (Angelone and Bini, 1992. Reproduced by kind permission of CRC Press and Lewis Publishers)

Country	Cu	Zn	Ni	Cr	Pb	Cd	Fe	Mn	B
Austria	17	65	20	20	150	0,20	13,300	310	
Belgium	17	57	33	90	38	0,33	1,638	335	32
Denmark	11	7	7	21	16	0,24	1,236	315	
France	13	16	35	29	30	0,74		538	21
Germany	22	83	15	55	56	0,52	1,147	806	
Greece	1,6	1,0	101	94	398	7,4		1,8	
Italy	51	89	46	100	21	0,53	37,0	900	
Netherlands	18,6	72,5	15,6	25,4	60,2	1,76			
Norway	19	60	61	110	61	0,95			
Portugal	24,5	58,4						328	59

End of table 3.3.1.1

Country	Cu	Zn	Ni	Cr	Pb	Cd	Fe	Mn	B
Spain	14	59	28	38	35	1,70			
Sweden	8,5	182	4,4	2,3	69	1,20	6,300	770	
England & Wales	15,6	78,2	22,1	44	48,7	0,70	3,1	1,4	
Scotland	23	58	37,7	150	19	0,47		830	
World soils	20	50	40	200	10	0,30		850	
US soils	25	54	20	53	20	0,50		560	
Canadian soils	22	74	20	43	20	0,30		520	
Excessive levels in soils	100	250	100	100	200	5		1,500	30

Table 3.3.1.1 shows values of heavy metal content in soils for European countries, Canada, and the USA (Angelone and Bini, 1992). The concentrations of each of the trace elements considered as excessive are also shown for comparison. The concentration of some heavy metals is much greater than the recommended excessive levels in some countries. Substantial variation in concentrations of various heavy metals among the countries demonstrate varying degrees of accumulation of these elements in soils as a result of differences in land use (Environmental geology, 1999).

Generally anthropogenic substances are accumulated in topsoil, that is why ***soil*** is a natural environment component, keeping long-term information about anthropogenic impact. Heavy metals occlude firmly and interact with humus forming sparingly soluble compounds and it favors their accumulation in soil. In addition, permanent migration of getting substances in soil and transporting them for long distances occur under different factors in soil.

3.3.2. Soil pollution monitoring organization in Russia

The main tasks of monitoring are:

a) detection of contaminated soils and determination of pollution causes and/or mechanical destruction;

b) detection of exhaustion degraded soils;

c) environmental impact assessment of soil pollution;

d) rehabilitation and abnormal soil restoration monitoring.

Lithogeochemical investigations method has been defied as works dealing with sampling and analysis soil pollution by different substances**.**

Soil pollution monitoring organization is carried out according to regulations and State Standards. Observations are carried out at stationary observation network. In Russia soil pollution monitoring is carried out in 100 towns by territorial subdivisions Rushydromet. Observations are also carried out at temporary field network – in towns and at areas of factories.

When forming uniform state system of soil pollution monitoring there are some official enumerations of standardized compounds in soil. The enumeration includes basically pesticides (about 140 names), mineral fertilizers (about 10 names), 10 heavy metals, some inorganic anions, sulphur, hydrogen sulfide, and also 10 organic compounds which are not toxic chemicals.

According to risk level chemical substances are divided into three classes: 1 – high hazardous substances; 2 – moderately hazardous substances; 3 – low hazardous substances. Assigning chemical substances to hazard classes is shown in table 3.3.2.1.

Industrial ecological soil pollution monitoring includes identification of polluted soils, determination of causes of pollution and chemical damages, assessment of soil pollution ecological effect. After assessment of soil and degraded lands pollution an enterprise must do activities connected with rehabilitation and control for renewal broken soils (recultivation).

Table 3.3.2.1

Assigning chemical substances, falling in soil from emissions and waste, to hazard classes (State Standard 17.4.1.02-83)

Class of hazard	**Chemical substance**
I	As, Cd, Hg, Pb, Se, Zn, F, benzo(a)pyrene
II	B, Co, Ni, Mo, Cu, Sb, Cr
III	Ba, V, W, Mn, Sr, acetophenone

For example, during soil monitoring in sanitary protection zone of enterprise it is necessary to determine soil pH and content of carcinogenic (it is determined in line with content benzo(a)pyrene) and radioactive substances; and from sanitary-bacteriological characteristics – determination of colibacillus bacteria. A number of polluted soil chemicals is controlled only under the known pollution source: ammonium nitrogen and nitrate nitrogen, chlorides, pesticides, heavy metals, oil and petroleum product, volatile phenols, sulphides, detergents, cyanides, polychloride xenyl (State Standard 17.4.2.01–81).

According to V.M. Fridland (1972) soils can be investigated by two methods: a) investigations at complex profiles and b) investigations at index sites.

a) Investigations at complex profiles. Practical application of this method depends on level of territory knowledge. If the regions don't have any information, which allows recognize spreading of different types of soil cover (SSC), first a medium-scale profile (usually 1:50000) is made. Next step of work is to make monocombinative large-scale profiles (usually from 1 : 25000 to 1 : 5000 subject to degree of combinations complexity), sites for these profiles are chosen in line with medium-scale profiles.

b) Investigations at index sites. Key investigations are investigations carried out at specially chosen sires (for example, the most anthropogenic transformed or background plot), and carried out in detail than investigations of whole studying territory. Scale of index sites depends on the structure of soil cover.

Sample sites on supposedly even polluted territory are embedded in **equidistant network**. Sample sites on supposedly uneven polluted territory are embedded in **inequidistant network**. The scale of lithogeochemical survey on the city and mining deposit territory is 1 : 25000, on territory of the industrial enterprise – 1 : 10000.

Local soil pollution – vectorial network with the different distance between points of sampling subject to distance from the source. Predominating wind direction takes into account. Sample sites are situated in line with relief elements if relief is heterogeneous.

Table 3.3.2.2

Sampling period of soil (State Standard 17.4.4.02-84)

Characteristic	Sampling period
Heavy metals concentration	One time a three years
For chemical, bacteriological, helminthological analyses	No less than one a year (spring or autumn)
Dynamics of soil self-cleaning	During 1 month weekly Then every month during vegetation period
Pollution soil monitoring of kindergartens, recreation areas of medicoprophylactic institutions	No less than twice a year (spring or autumn)
Factory area	One a year (spring or autumn)

For soil sanitary monitoring sample site is embedded in area which is equal triple size of sanitary–protection zone. *For agricultural land* soil pollution monitoring subjected to pollution sources, relief on every 0,5–20 hec. of territory no less than one sample site with size 10 × 10 m is embedded. For sanitary state of soil monitoring on territory of *kindergartens*, play grounds the size of sample site is 5 × 5 m. table 3.3.2.2 shows sampling period of soil.

3.3.3. Soil sampling and preparation

General soil sampling requirements take into account the vertical structure of soil, soil heterogeneousness, relief and climate of location, characteristics of contaminant and living organisms. Soil sampling requirements are regulated by the State Standards.

Soil profile sampling is carried out in a line with genetic horizons (A, AB, B, BC, C) or in a line with intervals 0–20; 40–60; 80–100; 100–200; 200–300 cm.

Sampling is carried out with soil corer (certain interval), or from pit or from small trench with metal-free instruments (e.g., shovel) (fig. 3.3.3.1).

Integrated sample is composed by mixing of single samples, taken from one sample site. Number of single samples took from one sample area depends on type of analysis, which will be used to study this sample (table 3.3.3.1). For example, to carry out chemical analysis the integrated sample is composed from five single samples took with a help of method of envelope from one sample area.

Point samples are meant to determinate volatile substances should be placed in flasks or glass stopper pots (bottles). Single samples for pesticides identification must not be taken in plastic bags.

Fig. 3.3.3.1. Soil sampling (left – soil corer (photo by Н.П. Ахментьева), right – from small trench (photo by А. Романчук))

During transportation they should be protected from secondary pollution.

Table 3.3.3.1

Sampling characteristics for identification of different substances (State Standard 17.4.4.02-84)

Kind of analysis	Depth	Number of single samples	Weight of sample
Radiochemical analysis	0–5 cm	5	Integrated sample – no less than 2,5 kg
Chemical analysis	0–5 cm	5	Integrated sample – no less than 1 kg
Surface-distributing substances (oil, petrochemicals, heavy metals)	layer-by-layer: 0–5 cm 5–20 cm	5	200 g every single sample

End of table 3.3.3.1

Kind of analysis	Depth	Number of single samples	Weight of sample
Migratory substances	in a line with genetic horizons whole depth of soil profile	Depend on the number of genetic horizons	200 g every single sample
Bacteriological analysis	layer-by-layer: 0–5 cm 5–20 cm	3 (10 integrated samples)	200–250 g every single sample
Helminthological analysis	layer-by-layer: 0–5 cm 5–20 cm	10	20 g every single sample

Five single measurements of gamma background and content of U-238, Th-232, K-40 isotopes on the area 5x5 m or 2x2 m are carried out by the method of envelope after sampling on the surface at sampling site. In the process of the soil gamma background measurement wit a help of СРП-68-01 its remote of detection has to be completely perpendicular to epipedon and not to be below 30 cm from it. In case of using РКП-305 to measure the isotope content its remote of detection has to be also perpendicular to epipedon and to be directly on it. From 3 to 5 measurements are carried out in one site sampling of soils.

Sample preparation to analysis is more important than sampling. It is carried out according to State Standard 17.4.4.02-84. Sample preparation consists of following stages: preliminary drying of soil, remove impurities, soil should be grinded and bolted with a help of sieve (diameter 1 mm).

Further procedures are carried out in a line with scheme of soil management (fig. 3.3.3.2).

3.3.4. Procedure of data processing

The basic criterion of chemical pollution of soil is maximum permissible concentration (MPC) and approximately permissible concentration (APC), and also background data (table 2.3.2).

If there are no MPC for some elements, background data are used. In this case results are calculated according to methodological recommendations (Методические …, 1982).

Concentration coefficient is shown the anomalous of element concentration relatively the background value. It is calculated by the formula (8):

$$KK = C / C_b, \quad (8)$$

KK – concentration coefficient; C – element concentration, mg/kg; C_b – background value of element concentration or geochemical the noosphere clarke, mg/kg.

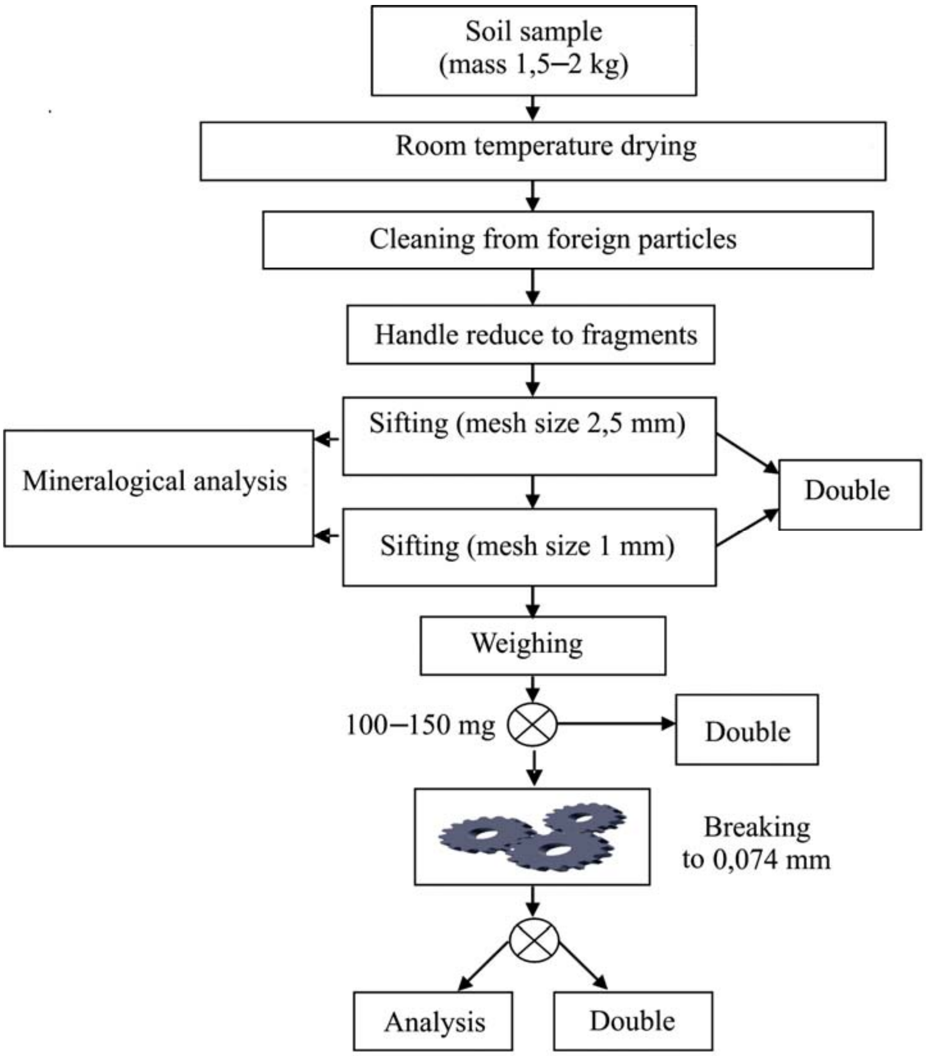


Fig. 3.3.3.2. Scheme of processing and studying of soil samples

According to coefficient concentration the geochemical row of element association from the highest value to the lowest value are constructed.

As the anthropogenic abnormalities usually comprise many elements, total pollution factor (Z_c) is calculated. It characterizes the impact of the group of elements. The factors are calculated by the formula (9):

$$Z_c = \sum KK - (n-1), \qquad (9)$$

n – a number of elements having KK values more than 1.

There is the following gradation for values of total pollution factor:

- less than 16 – low contamination level; safety morbidity level; lower change of children's health;
- 16–32 – middle contamination level; mildly unsafe morbidity level; increase in total morbidity;
- 32–128 – high contamination level; unsafe morbidity level; increase in total morbidity and number of illness children;

- more than 128 – very high contamination level; immensely unsafe morbidity level; very high level of morbidity, there are many children with chronic diseases and abnormalities in physical abilities.

In 2010 on the territory of Paris 20 samples were took by E. Ksenofontova. The content of heavy metals, rare earth and radioactive elements in samples was determined with neutron activation analysis in the nuclear-geochemical laboratory of Geoecology and Geochemistry Department. According to accounting results of concentration coefficient in relation to Clarke of the noosphere it was determined that Ca, Au, Sr, Hg, Zn possess maximum of concentration coefficient (fig. 3.3.4.1). On average for soils of the town territory the value of total pollution factor is 14, it is in line with low contamination level.

According to results of soil investigations on the territory of Tomsk it has been found that relative to background concentrations the accumulation of practically all studied elements except Sr and Eu occurs in soils. Integrated factor value of soil pollution by rare, rare earth, radioactive and other elements with concentrations coefficients more than 1 on average on the territory of Tomsk is 51 units. It is in line with high pollution rate. Elements Tb (*KK* = 7,7), Br (*KK* = 7,1), Sb (*KK* = 5,4) and Ta (*KK* = 5,3) make a main contribution to value of total pollution factor (Жорняк, 2009).

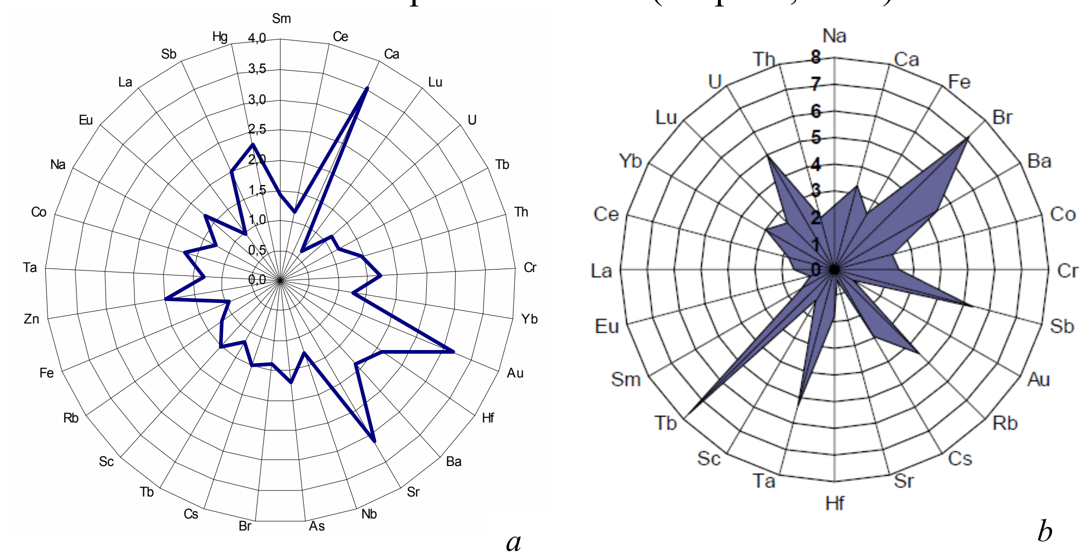


Fig. 3.3.4.1. Average value of concentration coefficient in soil of Paris (a) (Ксенофонтова, 2011) and Tomsk (b) (Жорняк, 2009)

3.3.5. Mineral and anthropogenic particles in soil

Besides calculations of geochemical characteristics we can exam material composition of soils and determine mineral and biogenic formations, and also we can determine anthropogenic particles with a help of modern methods of substances analysis. Natural mineral formation and anthropogenic particles can be determined with a help of modern methods according to patent № 2229738 (Yazikov E.G., Shatilov A. Yu., Bagazii T.V. The method of determination of soil contamination with anthropogenic components).

This section is made on basis of mineral composition studying of soil on urban territories of the south of the West Siberia (Язиков, 2006; Жорняк, 2009).

Both mineral and anthropogenic origin particles were diagnosed in soil. Material composition of natural-anthropogenic components in soils of urbanized territories with the different anthropogenic load level differs according to natural origin and anthropogenic origin particles and it is also determined by specificity of local pollution sources.

Mineral and biogenic particles.

1. Particles of quartz – transparent, colourless, angular, with vitreous luster; semitransparent, colourless or yellow-orange, gravel particles (fig. 3.3.5.1–3.3.5.3).

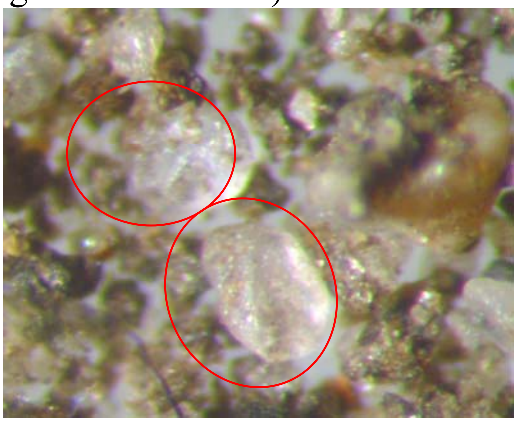


Fig. 3.3.5.1. Transparent quartz (binocular, magnification 50^x) (Жорняк, 2009)

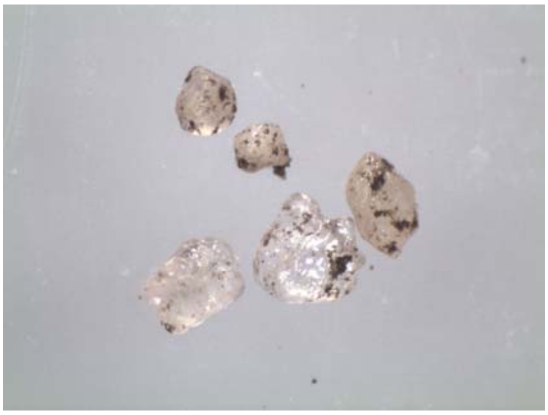


Fig. 3.3.5.2. Semitransparent quartz (binocular, magnification 50^x) (Жорняк, 2009)

2. Carbonates – milky semigravel particles of carbonate composition (fig. 3.3.5.4).

3. Iron oxides and hydroxides – brown or reddish irregularly-shaped fragile particles (fig. 3.3.5.5–3.3.5.6).

4. Mica flakes – vitreous luster, pearl, silvery-white or pale green semitransparent flat bedded particles (fig. 3.3.5.7).

5. Feldspars – reddish non-transparent semigravel particles.

6. Biogenic origin particles are presented by wood-vegetable residues, particles of seeds and insect (fig. 3.3.5.8).

7. Grey-brown, different forms, cemented, not compact particles, consisting of mainly small parts of quartz, iron oxides and hydroxides, and mud (fig. 3.3.5.9).

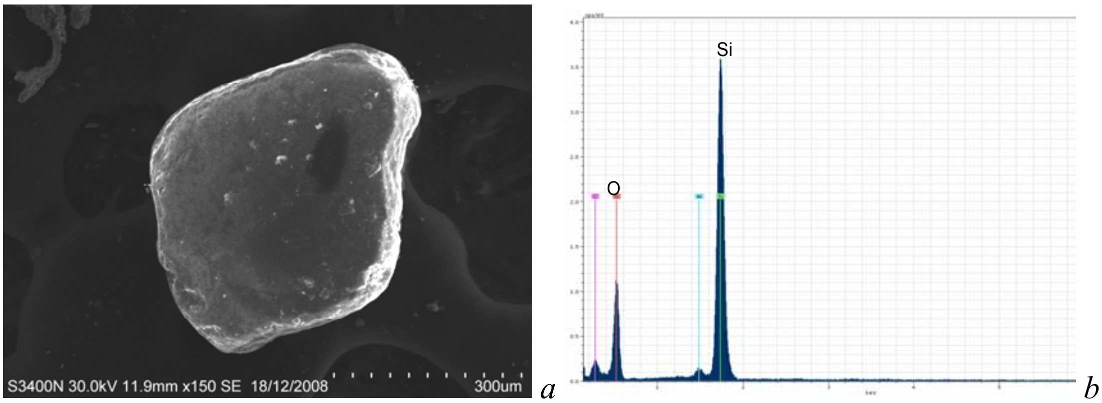


Fig. 3.3.5.3. Quartz:
a) photo of a particle (magnification 150ˣ);
b) energo-dispersive spectrum of quartz (electron microscopy results) (Жорняк, 2009)

Fig. 3.3.5.4. Carbonate particle
(binocular, magnification 50ˣ)
(Жорняк, 2009)

Fig. 3.3.5.5. Iron oxides
(binocular, magnification 50ˣ)
(Жорняк, 2009)

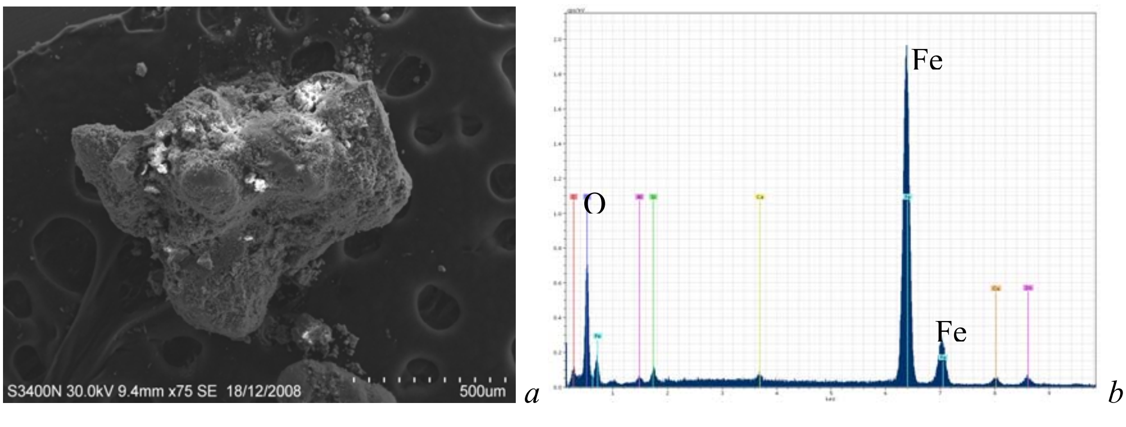


Fig. 3.3.5.6. Iron oxides:
a) photo of a particle (magnification 75ˣ); b) energo-dispersive spectrum of carbonate (electron microscopy results) (Жорняк, 2009)

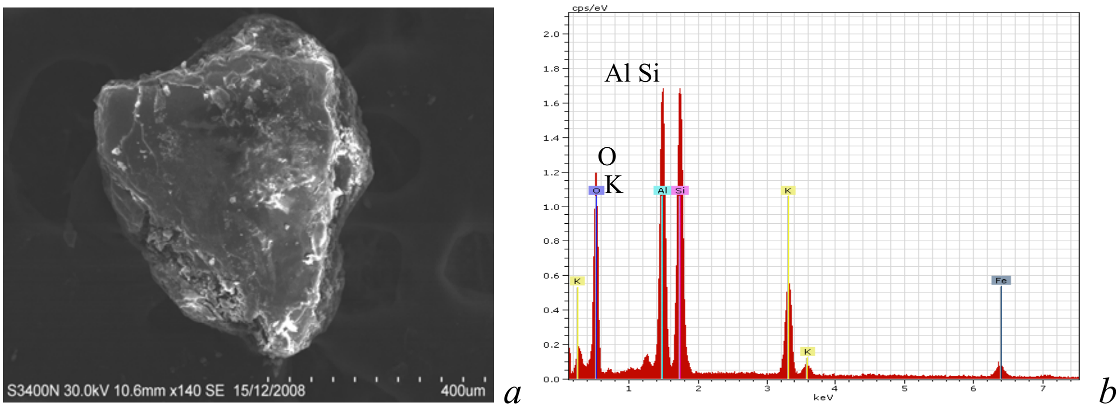


Fig. 3.3.5.7. Mica:
a) photo of a particle (magnification 140^x); b) energo-dispersive spectrum of mica (electron microscopy results) (Жорняк, 2009)

Fig. 3.3.5.8. Biogenic particle (binocular, magnification 50^x) (Жорняк, 2009)

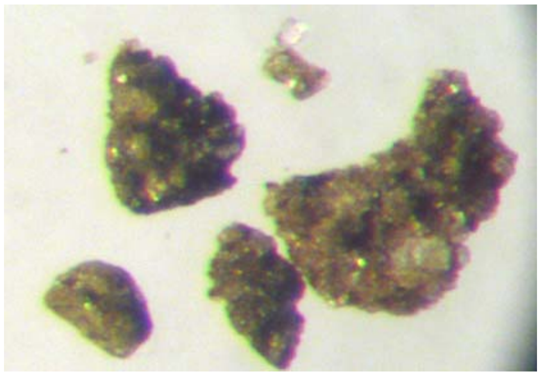


Fig. 3.3.5.9. Cemented particles (binocular, magnification 50^x) (Жорняк, 2009)

It should be noted that along with diagnosable particles there are particles which need to be studied more detailed.

Particles obtained in the process of burning of different sorts of fuel, household rubbish and also particles deal with different industrial technological processes are ***anthropogenic origin particles***.

In the process of soil sample investigation the following anthropogenic origin particles were discovered:

1. Prompt industrial scrap – tawny shapeless particles. According to laser microanalysis data they contain Fe, Ti, Mg, Cu, Mn, Si, Ca, Al, V and Li.

2. Ferromagnesite – dark grey or black, metallic luster microspherules possessing magnetic properties. They are typical of iron-foundry waste (fig. 3.3.5.10, 3.3.5.11).

3. Mullite – light grayish, greenish or brown, vitreous luster particles, possessing electromagnetic properties. They are typical of emissions of fuel-energy complex (fig. 3.3.5.10, 3.3.5.12, 3.3.5.13).

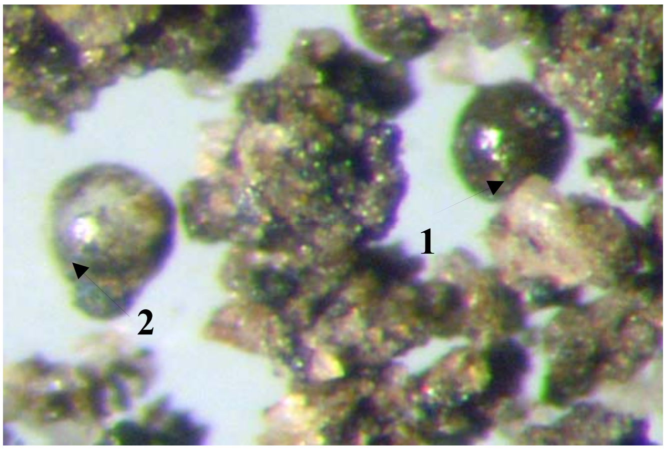


Fig. 3.3.5.10. Metal and aluminosilicate microspherules:
1 – ferromagnesite; 2 – mullite (binocular, magnification 60ˣ) (Жорняк, 2009)

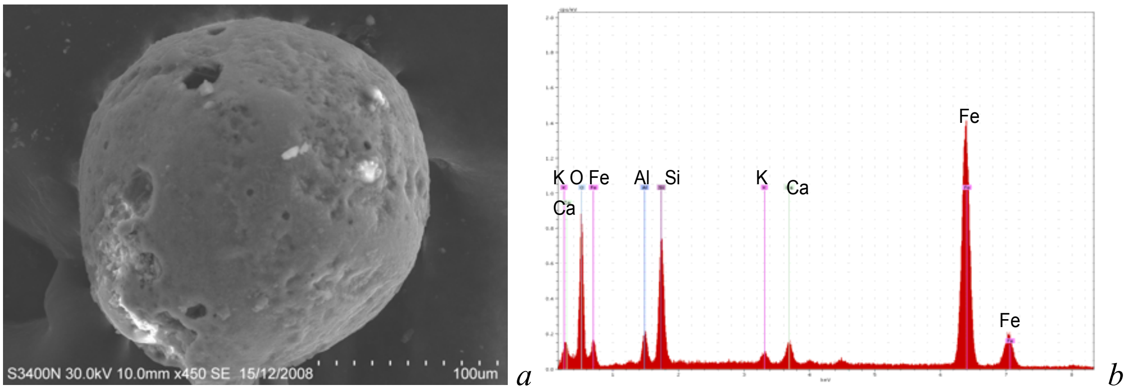


Fig. 3.3.5.11. Microspherules containing Fe:
a) photo of a particle (magnification 450ˣ); b) energo-dispersive spectrum of particle (electron microscopy results) (Жорняк, 2009)

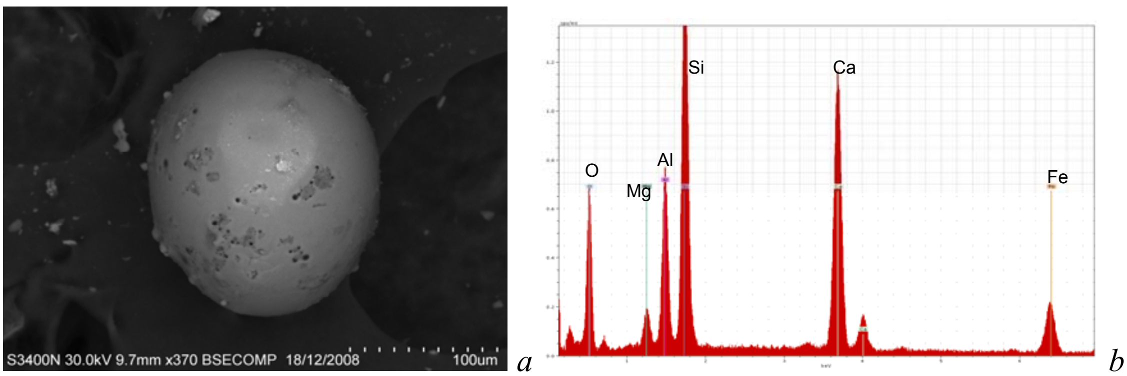


Fig. 3.3.5.12. Al-Si- microspherules containing Ca, Fe and Mg:
a) photo of a particle (magnification 370ˣ); b) energo-dispersive spectrum of particle (electron microscopy results) (Жорняк, 2009)

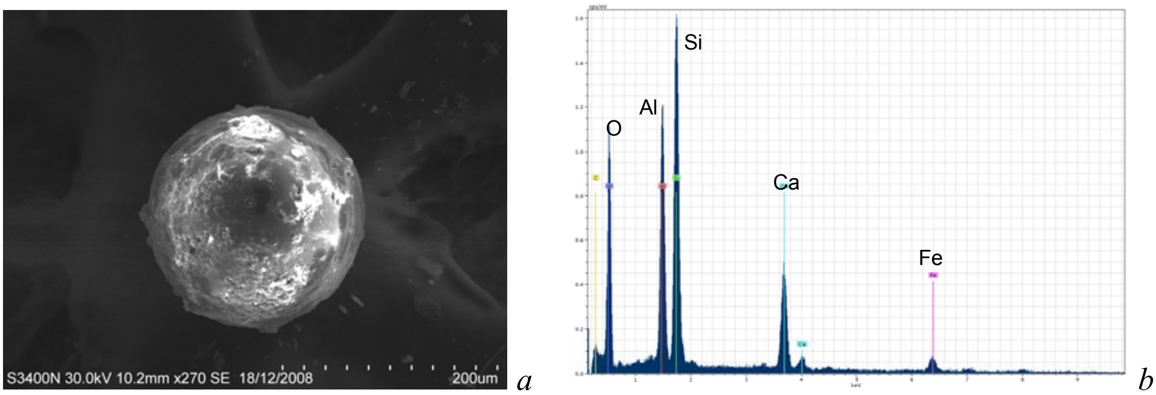


Fig. 3.3.5.13. Al-Si-microspherules with increased Ca content:
a) photo of a particle (magnification 270^x); b) energo-dispersive spectrum of particle (electron microscopy results) (Жорняк, 2009)

4. Grey, friable, irregularly-shaped ash particles. They were discovered in the soil sample collected near SPA "Virion" in Tomsk.

5. Crushed brick – orange-red friable particles.

6. Synthetic fibers – transparent, white, blue, violet, green or red-brown, vitreous luster, threadlike particles (villi) (fig. 3.3.5.14).

7. Red-brown, metallic luster particles of wire.

8. Particles of soot – small black flat friable particles. They are formed when burning different sorts of fuel or house rubbish.

9. Particles of slag – grey-black irregularly-shaped cemented particles. They possess magnetic and electromagnetic properties (fig. 3.3.5.15).

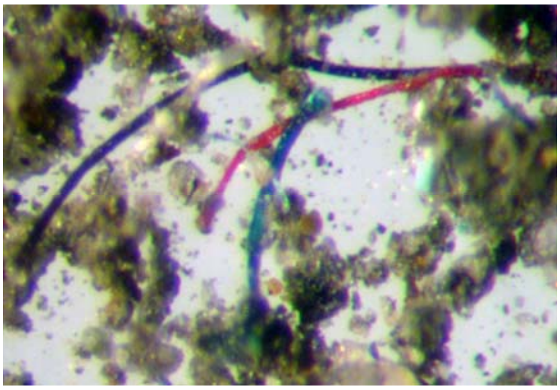


Fig. 3.3.5.14. Synthetic fibers (binocular, magnification 50^x) (Жорняк, 2009)

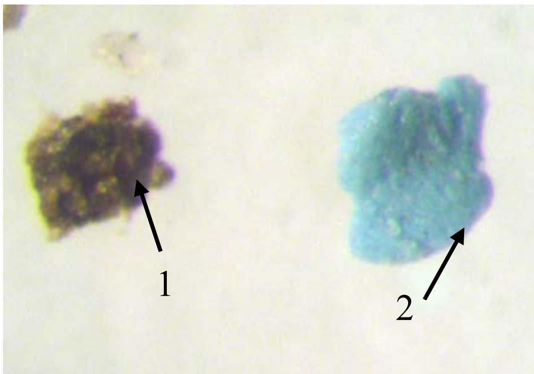


Fig. 3.3.5.15. A particle of slag (1) and a particle of paint (2) (binocular, magnification 50^x) (Жорняк, 2009)

10. Particles of lime – small white friable particles.

11. Particles of paint (fig. 3.3.5.15).

12. Particles of coal – black, greasy luster, angular irregularly-shaped particles. They pass to the environment due to emissions of coal-fired heating enterprises (fig. 3.3.5.16).

Colourless, white or greenish, vitreous luster, rod form semitransparent particles (fig. 3.3.5.17, 3.3.5.18) and brown-red irregularly-shaped ferruginous particles (fig. 3.3.5.19) and etc. are undiagnosed ones.

Mineral components presents mainly quartz, kaolin and orthoclase in soil samples collected on the territory of industrial plants of Tomsk. Hydrobiotite and biotite except basic component of all investigated samples were discovered in soils. For example, land-soil of industrial territory of OJSC "Sibelectromotor" Tomsk includes quartz, albite, microcline, mica, hematite and chlorite.

Proportion of mineral particles and anthropogenic origin particles directly depends on level of the anthropogenic load investigated territory.

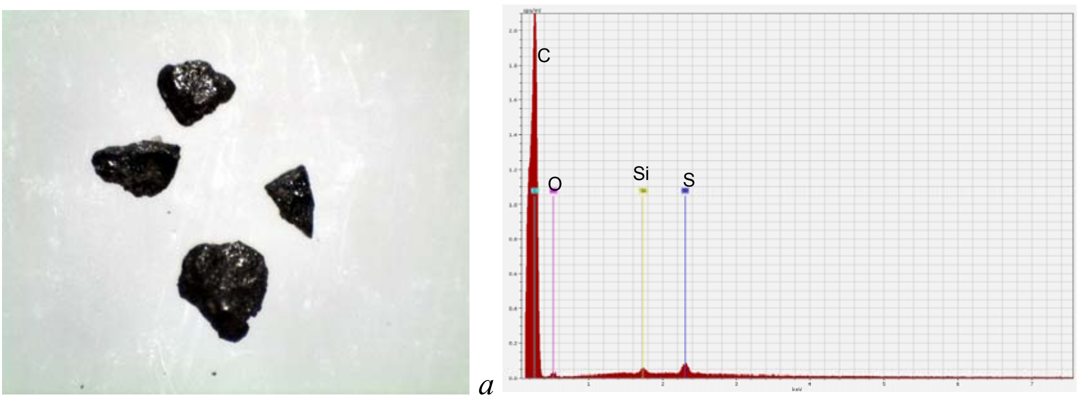


Fig. 3.3.5.16. Particles of coal:
a) photo of a particle (magnification 40^x); b) energo-dispersive spectrum of particle (electron microscopy results) (Жорняк, 2009)

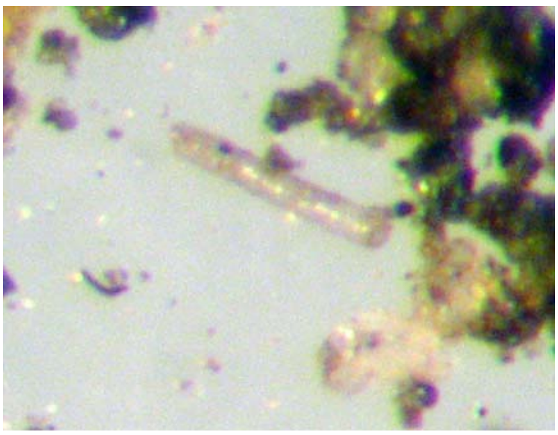


Fig. 3.3.5.17. Rod form semitransparent greenish particle (binocular, magnification 50^x) (Жорняк, 2009)

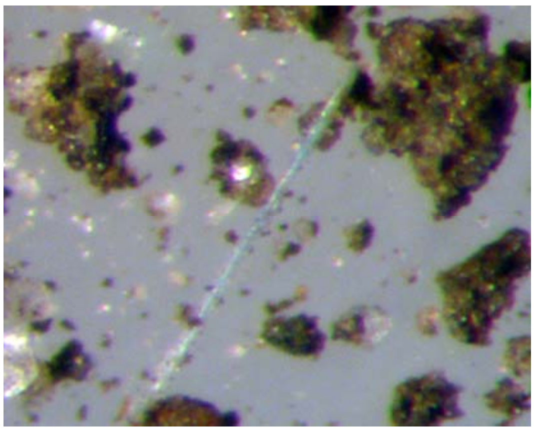


Fig. 3.3.5.18. Rod form semitransparent colourless particle (binocular, magnification 50^x) (Жорняк, 2009)

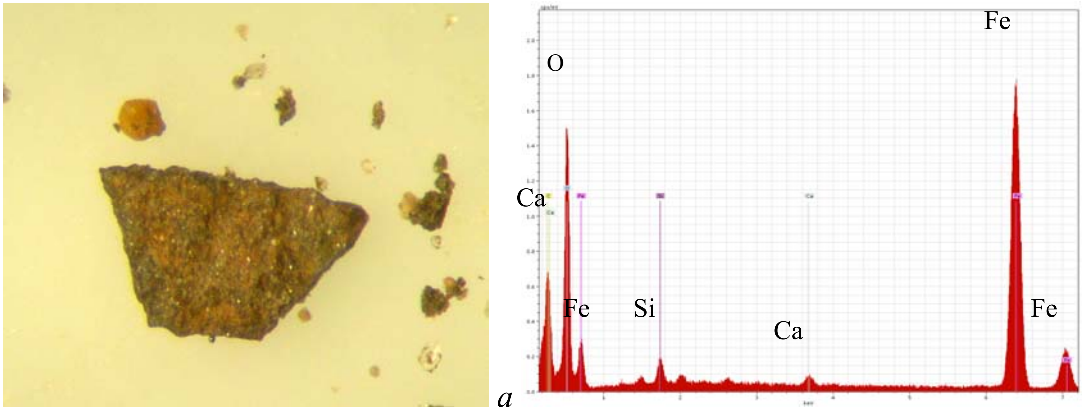


Fig. 3.3.5.19. Brown-red irregularly-shaped particle:
a) photo of a particle (magnification 50^x*); b) energo-dispersive spectrum of particle (electron microscopy results) (Жорняк, 2009)*

In background area (wildlife reserve "Tomsky") the mineral component is 96 % of sample, other part (4 %) is anthropogenic components presented mainly particles of coal, soot and slag when burning fuel in stoves and boiler rooms (fig. 3.3.5.20, 3.3.5.21).

Mineral component (on average 61 %) is practically predominant in all soil samples in Tomsk. Maximal percent of mineral component is accounted for by particles of quartz, carbonate particles, vegetable, biogenic and coherent particles. Maximal percent of anthropogenic component is accounted for by particles of metal-working, microspherules (mullite and ferromagnesite), particles of soot, slag and coal.

Maximum number of anthropogenic components in relation to mineral ones were discovered in soils of "Tomsk treating plant OJSC "Transwoodservice" (65 %), Tomsk GRES-2 OJSC "Tomskenergo" (64 %) and OJSC "Tomsk electromechanical plant" (53%) areas; minimum number of anthropogenic components – in soils near SPA "Virion" (16,5 %) and CJSC "Tomsk priborny plant" (19,5 %).

Comparing content of different anthropogenic particles in samples of Tomsk it is noted that the most prompt industrial scrap is in soil near OJSC "Tomsk electromechanical plant" (10 %); ferromagnesite is in samples collected in OJSC "Tomsky instrument", OJSC "Manotom'", LLC "Plant "Emalprovod", OJSC "Farmstandart-Tomskchemfarm" and CJSC "Tomsk yeast plant" areas (5 %); mullite and particles of ash are in soils near Tomsk GRES-2 (8 and 10 % appropriately); crushed brick is near LLC "Continent" (8%); rod form particles are near OJSC "Tomsk electolampovy plant and CJSC "Tomsk priborny plant" (3 and 4 % appropriately); particles of wire are in samples of CJSC "Sibcable" and its enamel production (1 %); soot is in samples of "Tomsk treating plant OJSC "Transwoodservice" (10 %): slag is soils near OJSC "Manotom'" (15 %); brown-red irregularly-shaped ferruginous particles are near OJSC "Tomsk radio engineering plant" (10 %); particles of coal are in soils near Tomsk GRES-2 and OJSC "Tomsk electromechanical plant" (20 %).

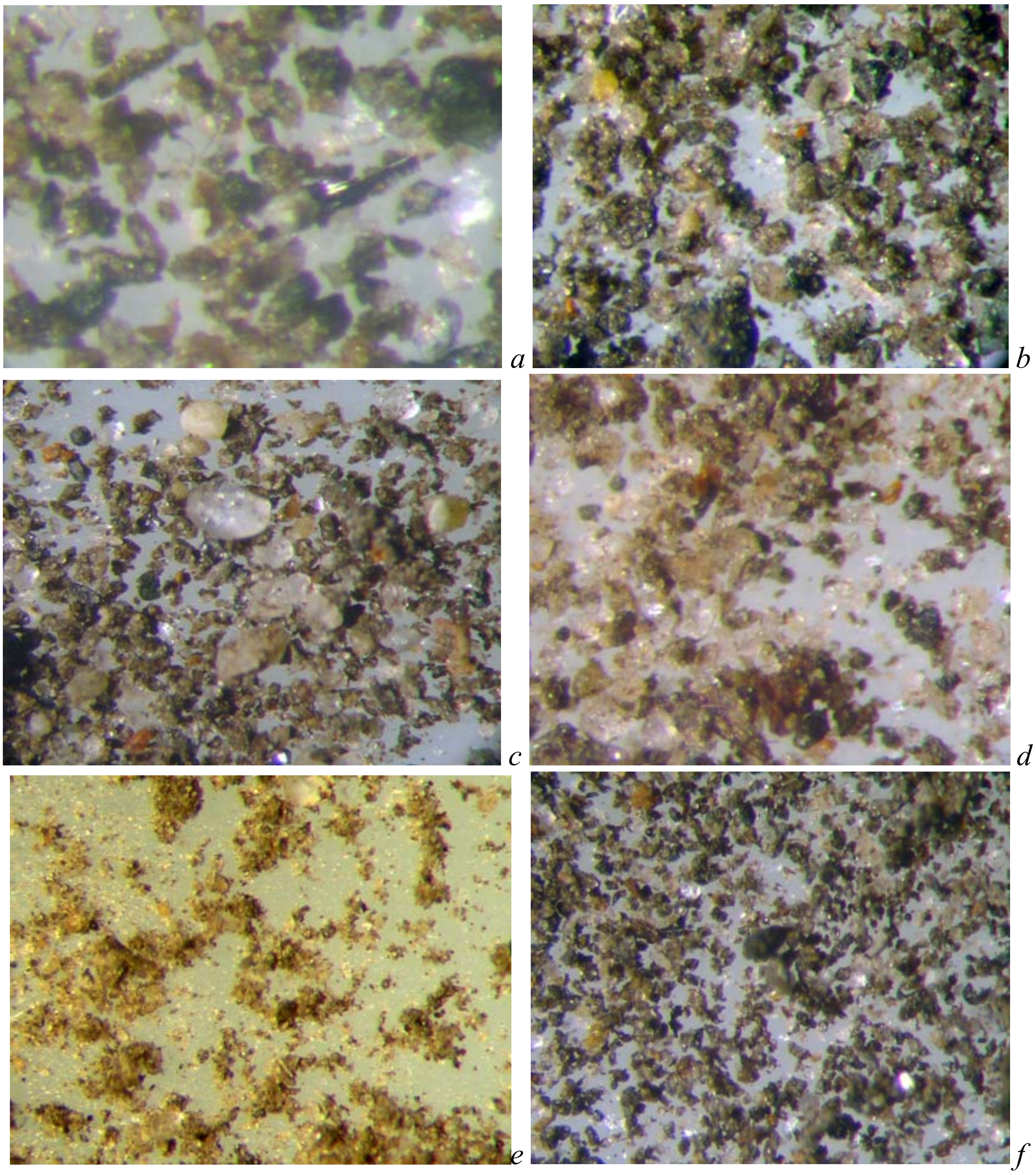


Fig. 3.3.5.20. General view of soil sample near industrial plants of Tomsk under binocular microscope:
a) OJSC "Tomsk electromechanical plant" (magnification 65^x);
b) OJSC "Tomsk electolampovy plant" (magnification 65^x);
c) OJSC "Tomsky instrument" (magnification 50^x); d) LLC "Plant "Emalprovod" (magnification 50^x); e) CJSC "Tomsk priborny plant" (magnification 50^x);
f)Tomsk treating plant OJSC "Transwoodservice" (magnification 50^x) (Жорняк, 2009)

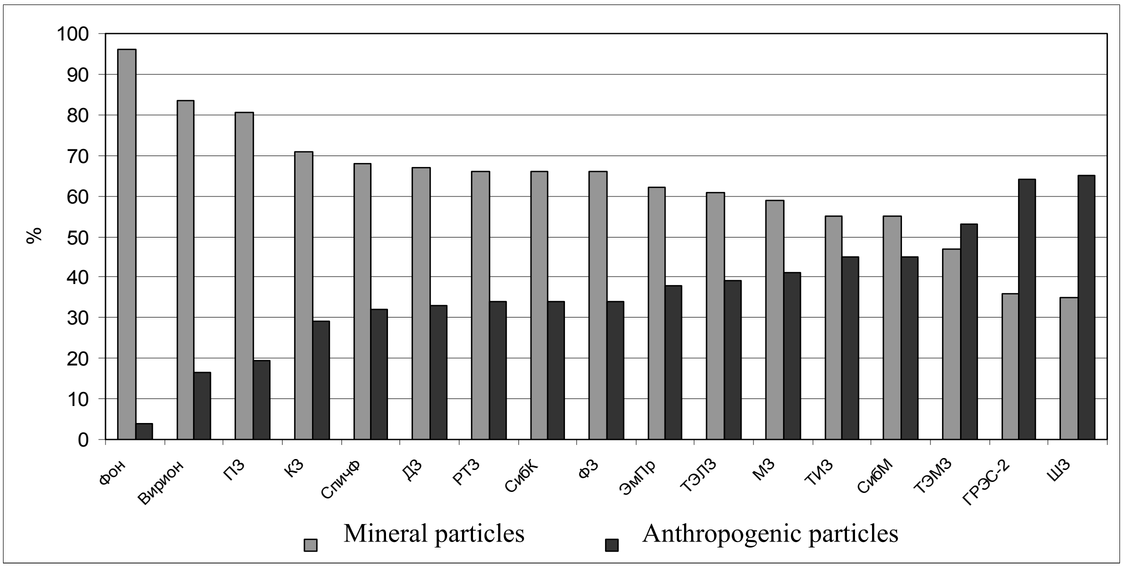


Fig. 3.3.5.21. Relation of mineral and anthropogenic particles in soil of industrial plants area (Tomsk) and background area:
фон – background area, wildlife reserve "Tomsky"; ПЗ – CJSC "Tomsk priborny plant"; КЗ – LLC "Continent"; СпичФ – OJSC "Tomsk match factory "Siberia"; ДЗ – CJSC "Tomsk yeast plant"; РТЗ – OJSC "Tomsk radio engineering plant"; СибК – CJSC "Sibcable"; ФЗ – OJSC "Farmstandart-Tomskchemfarm"; ЭмПр –LLC "Plant "Emalprovod"; ТЭЛЗ – OJSC "Tomsk electolampovy plant; МЗ – OJSC "Manotom'"; ТИЗ – OJSC "Tomsky instrument"; СибМ – OJSC «Sibelectromotor"; ТЭМЗ – OJSC "Tomsk electromechanical plant"; ШЗ – "Tomsk treating plant OJSC "Transwoodservice"

Coal-burning Tomsk GRES-2 and boiler rooms are the basic source of soot, slag, coal, ferromagnesite and mullite discovered in all investigated samples in Tomsk. Different anthropogenic particles pass to environment due to activities of industrial plants of the town, plants of building industry, overhaul and reconstruction parks, motor transport and private sector.

Revision

Review the questions:

1. What types of the network are used for lithogeochemical survey?
2. Describe snow sampling methods.
3. How soil sample preparation is performed?
4. Enumerate basic components analyzed in soil.
5. What types of anthropogenic components does soil consist of?

Answer the following questions:

1. Soil sampling is carried out according to:

a) intervals; b) horizons;
c) depths; d) age.

2. What should depth of soil sampling be to identify the heavy metal content in them?

a) 0–5 cm; b) 30–40 cm;

b) 20–30 cm; c) 5–20 cm.

3. Match the value with the contamination level determined according to the total pollution factor value:

1) Less than 16: a) high contamination level;

2) 16–32: b) very high contamination level;

3) More than 128: c) middle contamination level;

4) 32–128: d) low contamination level.

3.4. Biological and medico-geochemical monitoring

3.4.1. Biomonitoring general concepts

Biomonitoring has been defined as an environmental tracking system by means of biological objects.

Biomonitoring makes an opportunity:

a) to identify a wide range of contaminant, its effect on living organisms;

b) to assess previous environmental impacts;

c) to assess mutagenicity and biological activity.

Natural biological objects respond to changing of complex environmental parameters. Their changing is occurred on different levels of living matter – from molecular to populations and communities levels.

Biological objects accumulate information about environmental changes and respond to them over certain period of time.

Environmental biomonitoring can be carried out by such ways as – bioindication, biotesting and biochemical. *Bioindication* is meant to identify completed or accumulated pollutions in a line with indicated species of living organisms. *Biotesting* – carrying out analysis to identify toxicity with a help of living organisms. *Biochemistry* – studying of chemical composition of biological environments.

Biomonitoring methods are very effective economically. They don't require heavy expenses to buy equipment, and necessary information can be obtained simply and quickly.

Different kinds of animals, plants, microorganisms and lichen can be biotests. Lichenoindication is an assessment of air pollution level both in cities and in woodlands. Biomonitoring is carried out on population and individual levels. Morphological characters, their changes, species diversity are studied.

When biomonitoring is organized the bioindicators are made demands. They are following:

- accessibility on large spectrum of habitat during a year;
- staying on small territory and ability absence to strong migration;
- nutrition in polluted system and high level of metabolism;
- fast alternation of generations;
- easy breeding in the laboratory environment (Хаустов, Редина, 2008).

3.4.2. Organization of flora monitoring. Procedure of data processing

Plants are very sensitive object allowing assess all effect complex which is typical for this territory. Plants accumulate substances (for example, heavy metals) from soil, underground waters and atmospheric air simultaneously. It is better to use woody plants to characterize large territories. It is better to use grassy plants to identify microbiological differences.

Widespread species are chosen as model object. Plant sampling should be carried out in similar ecological conditions (brightness, humidity and etc.). For example, one of compared sampling should not be on the forest border and other – in the forest.

Plant sampling is carried out at the basic points of observation according to predominant (2-3) species which grow on the territory (fig. 3.4.2.1). Every plant is the independent sample.

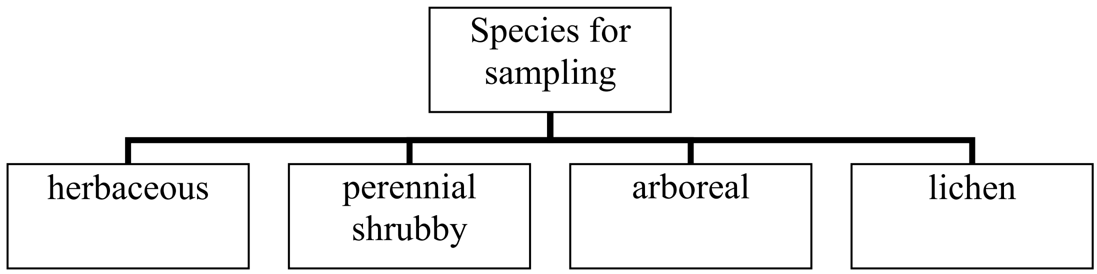


Fig. 3.4.2.1. Vegetation monitoring test-objects

Stages of *bioindication investigations*. First it is carried out *reconnaissance inspection* of territory in whole to identify the places of degradation vegetable cover, to identify fauna. Maps and other information are used for it. Medical plants and food plants, rare or endangered species are recorded separately. These data can be obtained in territorial nature conservation organizations.

If areas with high and medium degradation are discovered the index plots are laid where the observation are carried out. Vegetation sampling platform must be located near soil sampling sites. Regular observation areas must be fixed on the locality with a help of columns, and route observation areas must be fixed on the locality with a help of blazes on trees.

The functions of test-polygon lie in the fact that they are the etalon relative to areas, located in affected area. Data of biosphere reserves can be used as such areas at regional level.

At index plots route paths are made to obtain information about limits of degradation vegetable cover places. Route paths are carried out with using methods of floristics-geobotanical, zoological investigations and soil-geobotanical mapping.

In line with geobotanical investigation methods the size of sample plots varies 100 m^2.

Bioindication method is used to study species variety and anomaly of plants. On sample plot the leaves are collect from 10 different species of plants (10 leaves from every species of plants). In is necessary to collect materials after stopping intensive growth. For example, leaves should be collected to the end of May – the beginning June and before falling them in autumn. Periodicity is 1 time a 3–5 years.

Leaves from trees are collected to study their morphological properties. Leaves are collected from the bottom of crown of tree (raised hand level) from maximum numbers of accessible branches trying to use branches in all directions (south, north, east, west) (fig. 3.4.2.1). In whole 10–25 leaves should be collected from every species of tree (Захаров et al., 2001).

Fig. 3.4.2.1 Leaf sampling from trees (photo by А. Ялалтдинова)

Cameral treatment methods include studying of 5 parameters of leaf. Obtained data are tabulated. Then calculations of coefficient of fluctuating skewers of leaf are carried out. In line with obtained data ecological maps are made, these maps show environmental fairness level for life activity of organisms in every point of investigated territory. The most favorable plots are marked with green color, having deviations – shades of yellow subject to deviation level.

So called exhaust and gases, forming in result of burning of accompanying oil gas, burning of fuel in boiler plant have the most harmful effect to plants. Silver fir, fir tree, pine, lichen are the least tolerant of this kind of pollution. For example, pines have visible damage of across leaf under effect of harmful gases. The evidence of weak influence of harmful gases is blanching of needles. Russeting of needles say about extensive damage connected with flue gases. There are tests to determine the level of atmosphere pollution studying coniferous trees and lichen. Studying lichen it is determined that if the air is polluted a lot the lichen will be little.

Biogeochemical investigations allow study chemical composition of flora. The scale of biogeochemical survey on the urban territory is 1 : 100 000. The most pollutants are supposed to settle on the surface of vegetable sample and to be there in moving form. Dust and suspended particles, containing pollutants, stick to leaves, stems, fruit covered by wax-like substance.

Biogeochemical testing should be carried out in phase of phenological level of development of plants. Biogeochemical samples can be simple and compound.

The area is chosen to sample herbaceous vegetation. Grass is mowed down there, root system is analyzed separately. The root is cut down from the stem it is shaken carefully and it is put in the separate bag. The rest part is wrapped in cartridge paper.

Perennial bushes and trees are tested forming samples of the same parts of the plant (for example, leaves, bark and etc.).

Needles or leaves, browse, bark, root system are tested at lignose. Bark sample is selected from the 1,5–2 m height. Samples are selected not earlier than in 3 days after falling out of residue.

Plant sample is marked, indicating sample number, number of basic section and profile. Garden shears and knives are used for sampling. Leaves from trees and bushes are selected by hands in gloves.

Mass of biogeochemical sample is 100–200 g of moist matter. Mass of sample of plants with greater ash content can be 50–100 g. Method of sample preparation consist in drying and shred of sample; after that it is undergone by ashing (fig. 3.4.2.2).

There are two ways of ashing: “dry” – ashing in muffle furnace at high temperature (400–450°C). The indicator of complete ashing – homogeneous colouring of ash without visible coal lumps; “moist” – samples are treated by concentrated acids in turn the acid should be spectroscopically pure (Ковалевский et al., 1967; Ковалевский, 1991; Алексеенко, 2000). Optimum ashing conditions of plants are shown in table 3.4.2.1.

Table 3.4.2.1

Optimum ashing conditions of plants (Алексеенко, 2000)

Test material	Heating	Temperature, ºC	Time is necessary for ashing, hour
Pine (needles)	Rapid	450–550	2–3
Oak, hornbeam leaves	Rapid	450–550	0,5–2
Poplar, willow (leaves)	Rapid	450–550	0,5–2

Calculations are carried out on the base of chemical analysis of plant ash according to methodic recommendations (Методические …., 1982).

Concentration coefficient is shown the anomalous of element concentration relatively the background value. It is calculated by the formula (10):

$$KK = C / C_b, \quad (10)$$

KK – concentration coefficient; C – element concentration, mg/kg; C_b – background value of element concentration or geochemical the noosphere clarke, mg/kg.

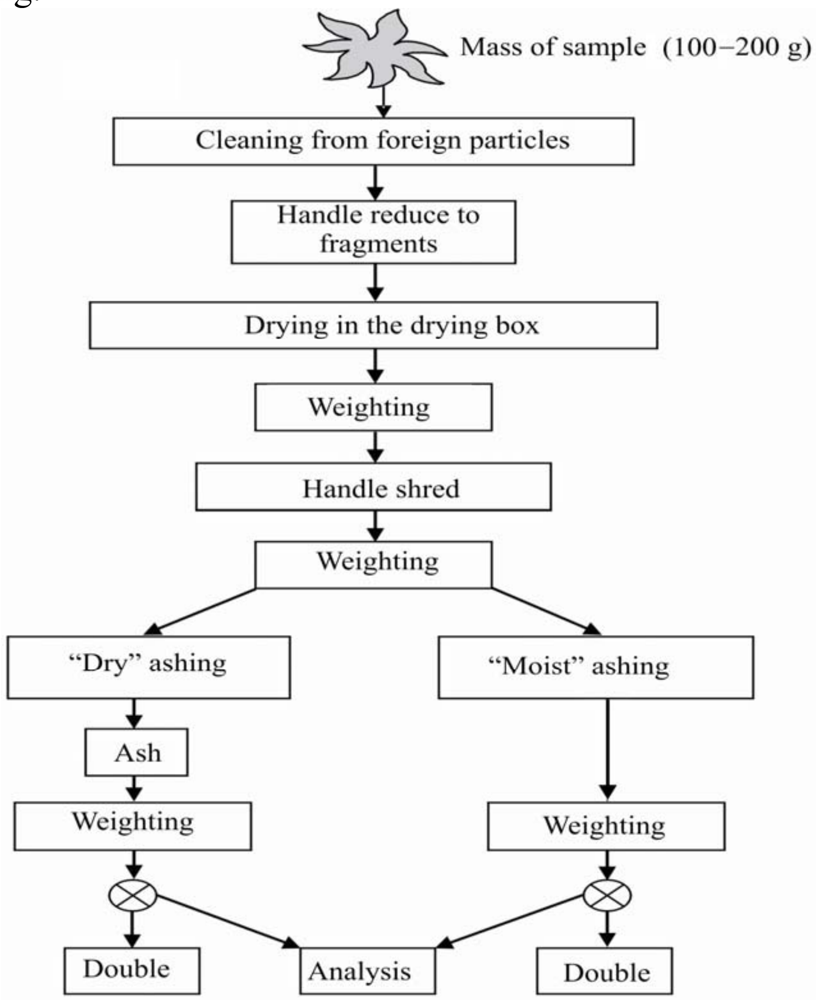


Fig. 3.4.2.2. Scheme of processing and studying of plant samples

According to concentration coefficient the geochemical row of element association from the highest value to the lowest value are constructed.

As the anthropogenic abnormalities usually comprise many elements, total pollution factor (Z_c) is calculated. It characterizes the impact of the group of elements. The factors are calculated by the formula (10):

$$Z_c = \sum KK - (n-1), \tag{10}$$

n – a number of elements having KK values more than 1.

The absorption coefficient (***Ax***) relative to this element content in soils is calculated according to the formula (11):

$$A_x = C_{xash} / C_{xsoil}, \tag{11}$$

C_{xash} – element concentration in plant ash, mg/kg, C_{xsoil} – element concentration in soil, mg/kg.

3.4.3. Medico-ecological and medico-biological monitoring

In modern society the environmental condition is understood to be a factor having an influence on human health. This is proved by the fact that according to data of World Health Organization (WHO) the share of this factor is about 20 % unit impact determining the level of human health.

Unfavourable factors of natural environment both anthropogenic and natural have an effect on the level of human health. Spectrum of these effects is quite broad.

Medico-ecological researches are the studying of the level of adult population and teenager health. It is estimated by official statistics. The disease list is quite wide. Each region data can be inquired in medical centers and also official reported data can be used.

The regularity of function and sickness rate of population according to environmental pollution is found and it found its way into methodological recommendation of the USSR Ministry of Health (№ 4266-87), in the form of determined total pollution factor (TPF) (fig. 3.4.3.1).

Along with public statistical data it is necessary to carry out medico-biological investigations of human biosubtrata. If blood and urine can characterize a short-term period of the microelement content and composition of food and water can have an impact on this period, nails and hair are long-term depositing environment.

Long-term investigations of hair carried out by A.A. Kist and L.I. Zhuk (1991) allowed expose the correlative connection between sickness rate and chemical composition of hair. To make a sampling it is necessary to remember that the hair microelement composition of adults will be determined by specific character of man's job whereas to determine background characteristics it is necessary to analyze children's hair.

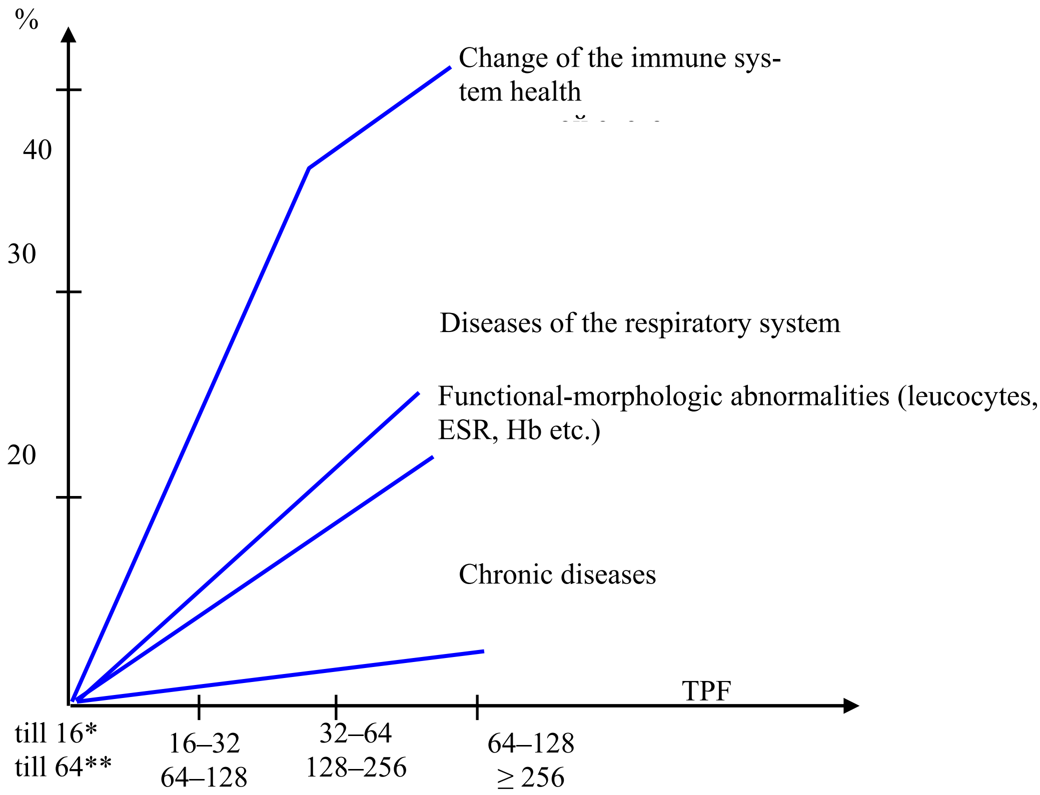


Fig. 3.4.3.1. Frequency of child level of health according to total pollution factor for soil and snow** (Геохимия..., 1990)*

Revision

Review the questions:

1. What indicators are used when biomonitoring is carrying out? What parameters are they chosen by?

2. Formulate basic demands deals with location of the vegetation biomonitoring site.

3. Characterize sampling techniques of different types of vegetation when using biogeochemical method.

4. How plant sample preparation is performed for biogeochemical method?

5. How does medico-ecological monitoring differ from medico-biological one?

Answer the following questions:

1. Choose types of biological monitoring and give a definition of them:

a) geochemical;	b) biogeochemical;
c) indication;	d) bioindication;
e) biotesting;	f) medico-biological.

2. How many leaves of one type of vegetation should be collected on a sample area?

a) 20; b) 30; c) 10; d) 100.

3. Match the factor with its formula:

1) total pollution factor:	a) $A_x = C_{xash} / C_{xsoil}$;
2) coefficient of biological uptake:	b) $KK = C / C_b$;
3) concentration coefficient:	c) $Z_c = \sum KK - (n-1)$.

3.5. Water pollution monitoring

3.5.1. Water pollution

An important distinction in water quality is whether a pollutant comes from a *point source* such as a waste treatment plant or industrial outfall pipe, or *non-point source* such as runoff from agricultural fields. More than 85 per cent of the water quality impacts in the United States, and more than 50 per cent of the water quality impacts in the world are due to non-point sources. Nonetheless, the majority of early water quality legislation has focused almost exclusively on point sources as these are easier to regulate.

Virtually every land use has the potential to change water quality. Actual effects vary enormously depending on the volume of a pollutant discharged into the waters, its concentration, speed of delivery, the water renewal rate of a body of water and the nature of the specific stressor. The ten major impacts on water quality are: changes in suspended sediment load, organic matter and biological oxygen demand, bacteria and viruses, nutrient loads, temperature, heavy metals, toxins such as pesticides and herbicides, acidification, salinization, and changes in the flow of water, itself (table 3.5.1.1) (Environmental geology, 1999).

Pollution of water bodies – discharge or waste input by another means in water bodies and also formation of harmful substances deteriorating quality of surface and underground waters, limiting use or negatively influencing on bottoms and banks of water bodies.

Sewage water is water which after using for industrial and domestic needs is disposed resulting from production facilities, mining, industrial sites of plants, towns and villages.

To maintain water bodies according to ecological requirements, to prevent pollution, depletion and clogging of surface water and also to reserve fauna and flora in Russia the water protection zones are located.

Table 3.5.1.1

Sources and impacts of selected pollutants (Reproduced from WRI, 1992, p. 162, with permission from the World Resources Institute)

Pollutant	Source	Impact on aquatic organisms	Impact on human health and welfare
Sediment	Agricultural fields, pastures, and livestock feedlots; logged hillsides; degraded streambanks; road construction	Reduced plant growth and diversity; reduced prey for predators; clogging of gills and filters; reduced survival of eggs and young; smothering of habitats	Increased water treatment costs; transport of toxics and nutrients; reduced availability of fish, shellfish, and associated species; shortened lifespan of lakes, streams, and artificial reservoirs and harbors
Nutrients	Agricultural fields, pastures, and livestock feedlots; landscaped urban areas: raw and treated sewage discharges; industrial discharges	Algal blooms resulting in depressed oxygen levels and reduced diversity and growth of large plants; release of toxins from sediments; reduced diversity in vertebrate and invertebrate communities; fish kills	Increased water treatment costs; risk of reduced oxygen-carrying capacity in infant blood; possible generation of carcinogenic nitrosamines; reduced availability of fish, shellfish, and associated species; impairment of recreational uses
Organic materials	Agricultural fields and pastures; landscaped urban areas; combined sewers; logged areas; chemical manufacturing and other industrial processes	Reduced dissolved oxygen in affected waters; fish kills; reduced abundance and diversity of aquatic life	Increased costs of water treatment; reduced availability of fish, shellfish, and associated species
Disease-causing agents	Raw and partially treated sewage; animal wastes; dams that reduce water flow	Reduced survival and reproduction in fish, shellfish, and associated species	Increased costs of water treatment; river blindness, elephantiasis, schistosomiasis, cholera, typhoid, dysentery; reduced availability and contamination of fish, shellfish, and associated species
Heavy metals	Atmospheric deposition; road runoff; industrial discharges; sludge and discharges from sewage treatment plants; creation of reservoirs; acidic mine effluents	Declines in fish populations due to failed reproduction; lethal effects on invertebrates leading to reduced prey for fish	Increased costs of water treatment; lead poisoning, itai-itai, and Minamata diseases: kidney dysfunction: reduced availability and healthiness of fish, shellfish, and associated species

End of table 3.5.1.1

Pollutant	Source	Impact on aquatic organisms	Impact on human health and welfare
Toxic chemicals	Urban and agricultural runoff; municipal and industrial discharges; leachate from landfills	Reduced growth and survivability of fish eggs and young; fish diseases	Increased costs of water treatment; increased risk of rectal, bladder, and colon cancer; reduced availability and healthiness of fish, shellfish, and associated species
Acids	Atmospheric deposition; mine effluents; degrading plant materials	Elimination of sensitive aquatic organisms; release of trace metals from soils, rocks, and metal surfaces such as water pipes	Reduced availability of fish, shellfish, and associated species
Chlorides	Roads treated for removal of ice or snow; irrigation runoff; brine produced in oil extraction; mining	At high levels, toxic to freshwater life	Reduced availability of drinking water supplies; reduced availability of fish, shellfish, and associated species
Elevated temperatures	Urban landscapes; unshaded streams; impounded waters; reduced discharges from dams; discharges from power plants and industrial facilities	Elimination of cold-water species of fish and shellfish; reduced dissolved oxygen due to increased plant growth; increased vulnerability of some fishes to toxic wastes, parasites, and diseases	Reduced availability of fish, shellfish, and associated species

Sources: Meybeck *et al.* (*1989*, pp. 107, 159, 160, 163); Miller (*1991*, p. 248); Mitchell and Stapp (*1990*, p. 51, p. 54); Muirhead-Thomson (*1988*, p. 71); Nimmo *et al.* (*1987*, pp. 58–62); OECD (*1986*, pp. 50–2); Petersen (*1984*, p. 140); Schueler (*1987*, pp. 1.5–1.9) and US EPA (*1989*, p. 9, p. 11).

Water protection zone is a territory bordering on water front of seas, rivers, streams, channels, lakes, water-storage basins. The special regime of economic business management or different type of activity is formed according to the Water Code of the Russian Federation. The width of river and stream water protection zone is defined from the river or stream head according to their length.

3.5.2. Arrangement for surface water monitoring in Russia

Arrangement for state monitoring of water bodies as the observation system, assessment and forecast of water bodies under the State ownership, municipal entities, individuals and companies is covered by the Water Code of the Russian Federation. State monitoring is considered to be as a part of state monitoring of environment.

Systematic monitoring of surface water quality at network of stationary posts is carried out by Russia Federal service of hydrometeorology and environmental monitoring (Rushydromet). In addition, water quality observation is carried out by Federal Service for Supervision of Consumer Rights Protection and Human Welfare (Rospotrebnadzor), Federal Service for Environmental Technological and Nuclear Supervision (Rostekhnadzor) and also by ecological services of plants using water resources according to specified requirements.

Water sampling works and analysis of water polluted by different substances are usually called ***hydro(geo)chemical investigations***, and physical parameter observations are called ***hydrological investigations***. Natural waters' quality is estimated by physical parameters (water discharge, flow velocity, level of water – hydrometric measurements, temperature – thermometer, colour of water, smell – visual method), chemical, sanitary-bacteriological and hydrobiological parameters.

Arrangement strategy of observations at controlled stations is covered by State Standards and by methodological instructive regulations dealing with water quality of streams and water bodies.

To monitor continental waters it is necessary to arrange:

- *Stationary network of* natural composition and surface water pollution observation stations.
- *Proprietory network of monitoring stations.* It is necessary to solve research tasks on polluted water bodies; to solve operating objectives and to make forecasts; to study the process of build-up pollutants in bottom deposits and to study their impact on water quality.
- *Temporary field network of stations.* It is necessary to obtain the water body data which are not overcome by stationary and special observations. As a rule, they are one-off researches of rivers condition. The aim of these researches is to do visual examination of streams; to specify places and wastewater conditions, the amount of wastewater and their composition; to identify the section of complete mixing of river waters and wastewaters; to find out pollutants which they are typical of pollutants of this observation station. Single sample of water is analyzed.

Observation stations of surface water quality are subdivided into 4 categories at these networks (table 3.5.2.1).

Table 3.5.2.1

Periodicity of monitoring and kinds of hydrochemical monitoring program (ГОСТ 17.1.3.07–82)

Periodicity of monitoring	Categories of observation station			
	1	2	3	4
Every day	Reduced program 1	Visual observations	–	–
Each decade	Reduced program 2	Reduced program 1	–	–
Every month	Reduced program 3			–
In basic phase of hydrological regime	Mandatory program			

Note: 1) Mandatory program: water discharge, flow rate, visual observations, colour, temperature, transparence, smell, water-dissolved oxygen and carbon dioxide, turbidity, pH, Eh, chlorides, sulphates, hydrocarbonates, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, total salt content, chemical oxygen demand (COD), biological oxygen demand in 5 days (BOD_5), NO_2^-, NO_3^-, NH_4^+, phosphates, total iron, silicon, oil products, synthetic surface active substances (SSAS), phenols, metals (they are determined subject to the enterprise profile); 2) Reduced program 1: water discharge, visual observations, temperature, water-dissolved oxygen, electrical conductivity; 3) Reduced program 2: water discharge, visual observations, temperature, pH, electrical conductivity, turbidity, chemical oxygen demand (COD), biological oxygen demand in 5 days (BOD_5), concentration of 2-3 pollutants which are the basic ones at this station; 4) Reduced program 3: water discharge, flow rate, visual observations, temperature, pH, turbidity, water-dissolved oxygen, chemical oxygen demand (COD), biological oxygen demand in 5 days (BOD_5), concentration of all water pollutants at this observation station. Chemical elements and metal distribution monitoring (including components of total salt composition) is carried out in basic phases of hydrological regime or every month.

The category of observation stations and their location area are determined subject to complex of factors such as population of a town, breeding areas, level of water pollution determined by excess of maximum permissible concentration (MPC). The 1-st and 2-d category observation stations are placed on the territory of large plants, on the areas where emergency discharges are repeated and on the areas where there is a high level of pollution (from 10 to 100 MPC). The 3-d category observation stations are placed on the territory of medium-size enterprises, in outlets of rivers, on the organized sewage disposal areas where systematic water pollution according to one or several pollutants reaches 10 MPC. The 4-th category observation stations are placed on unpolluted areas of water bodies and streams.

Water quality observation is carried out according to definite programs chosen subject to the category of observation station (table 3.5.2.1).

Materials, the list of controlled substances on basis of the determined standard of maximum permissible discharge are used to design the system of operational environmental monitoring at the plant.

3.5.3. Surface water sampling and preparation

Regulations of sampling, transportation, sample preparation for storage and also the regulations of sample instruments, devices for storage and water sample acceptance in the lab and sample analysis of surface water are regulated by Russian State Standards.

To place monitoring sites it is necessary to know everything about pollution source locations and also to know width, depth, flow velocity of the stream. One or two points are formed at the monitoring site.

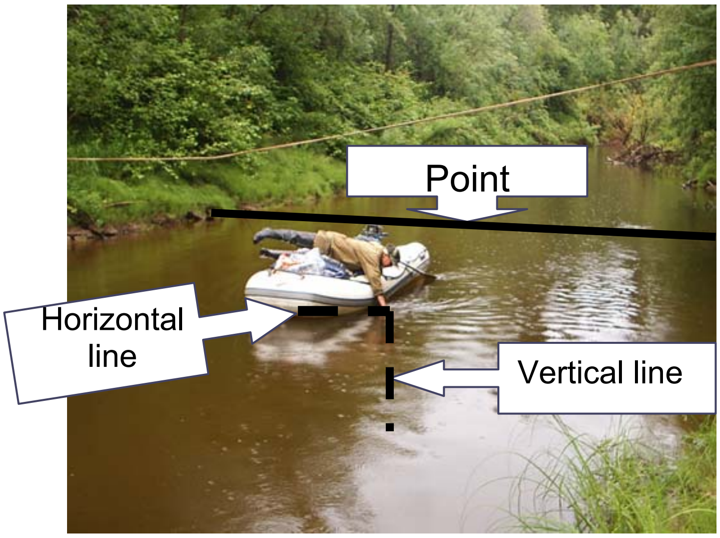


Fig. 3.5.3.1. Schematic view of point, horizontal and vertical line at surface water sampling site

The monitoring site point is the conditional cross-section of a water body and a stream where the works dealt with water quality data are carried out.

If there is no organized disposal of sewage it is necessary to place one point in mouths of polluted inflows and also on the unpolluted stream segments, on the river stretches situated before a dam, on the closed river stretches, at the place of border crossing.

One or several points are organized at the monitoring site. If there is an organized disposal of sewage, one point is located 1 km up from disposal of sewage (it is considered to be background), other points are located down. To choose location it is necessary to take into account characteristics of sewage and river water mixing. As a rule, downstream point is situated in a zone of complete mixing in 500 m. If there are groups of pollution sources, the upstream point (background) is situated upper of the first source and the downstream point is situated down of last one.

To observe water quality of the whole water body no less than three points, equidistributed all over the water surface and taken into account water-front, are located on the water bodies (lakes, ponds).

If the stream has got several branches, the points are located on those of them where the maximal quantity of flow and the irregularity of water quality are observed.

Vertical lines and horizontal lines are placed on every point. Their location and quantity are determined by the type of discharges, characteristics of water body and conditions of bottom configuration.

Vertical line is a conventional tire vertical from the surface of water (or ice) to the bottom of water body or stream. It is needed to obtain data about water quality indicators.

The quantity of tested vertical lines in a point is determined by conditions of mixing: if there is a heterogeneous chemical composition, no less than three vertical lines are placed in the point – on the line of fastest flow and at the banks; if there is a homogeneous chemical composition, only one vertical line is tested – on the midstream (Методические …, 1985).

If streams are not too deep (2–3 m), water samples at the observation points are sampled when the depth is 0,2–0,5 m. Narrow width of bed (20–30 m) gives the possibility to sample one sample on the line of fastest flow. But it is more reasonable to sample three samples (on the line of fastest flow and close to the banks) on all streams; after that these samples are averaged at the sampling location. When work is carried out on the large rivers it is possible to sample from different horizontal lines. As a rule, sampling is carried out by three vertical lines (on the line of fastest flow and close to the banks) from three levels (surface level, middle level and near-bottom level).

Horizontal line is a place on the vertical line (in depth) where data about water quality indicators are obtained. Amount of horizontal line on the vertical line is determined subject to depth of water body (table 3.5.3.1).

Table 3.5.3.1

Amount of horizontal line on the vertical line at surface water sampling post (GOST 17.1.3.07–82)

Depth of stream, m	Amount of horizontal lines	Sampling depth
to 5 m	1	In summer – 30 cm from surface of water In winter – at bottom of ice
5–10 m	2	The first – at surface of water The second – 50 cm from bottom of water body
over 10 m	3	Mid-shaft – at half of water body depth
over 50 m	over 5	The first – at surface Next four – 10, 20, 50, 100 m The fifth – at the bottom

According to operating regime all sampling instruments and devices are subdivided into automatic, semiautomatic and hand-hold ones. At present hand-hold sampling instruments and devices are generally used. Sampling is usually carried out in special containers (bottles, buckets) or facilities (bathometers). Different types of bathometers are used on the largest rivers especially when sampling from depths. According to small and not large rivers glass or squeeze bottles and buckets are used. Sampling is carried out with a help of floating crafts.

Before use containers and devices used for sampling and transportation are washed carefully by concentrated hydrochloric acid. Synthetic detergents are used for removal of fat. Residues of used for washing reagent are completely removed by careful washing of containers with a help of tap and distilled water. Such kind of procedure is recommended to carry out from time to time. During sampling the containers should be rinsed several times by investigated water. The specific containers are appointed to concrete points in the process of work. This fact reduces considerably probability of secondary sample pollution. Water sampling is not allowed by instruments and containers made from metal or by instruments and containers including metal parts. It is not also allowed to keep samples in metal containers before analysis.

Water sample volume depends on investigated components and the method of determination of investigated component concentration. pH value is determined in samples directly on the position of sample. To carry out water analysis for Cu, Zn, Pb, Ni, Co, U, Ra the water has to be acidified with hydrochloric acid (3 ml per 1 liter of water), and to carry out water analysis for Hg and Ag the water has to be acidified with sulphuric acid (3 ml per 1 liter of water). Acid should be “spectroscopically pure” (Алексеенко, 2000).

Hydrochemical sampling should be accompanied with records in the sample record book, sampling post mapping, making out a sample certificate. The certificate of sample can be fastened to the bottleneck or can be written.

Total water sample volume for chemical analysis from every point is from 5 to 8 liters.

Maximal storage period of sample with preservatives should not exceed two weeks. The sample should be kept in the dark at temperature 3–7 ºC. In exceptional cases it can be done without preservatives, but the sampling and analysis interval should not exceed 1–2 days.

After sampling and transportation in the laboratory (field or stationary lab) they are filtrated immediately. It is carried out to separate dissolved and suspended forms of chemical elements. Membrane filters holed 0,4–0,5 micrometers, nuclear (mylar) and inexpensive widely-spread nitrocellulose filters can be used subject to assigned tasks. Suspension on filters, the sediment and separation suspension can be kept under appropriate conditions (cool dark place) for a short time. The scheme of water sample treatment and analysis is shown in fig. 3.5.3.1.

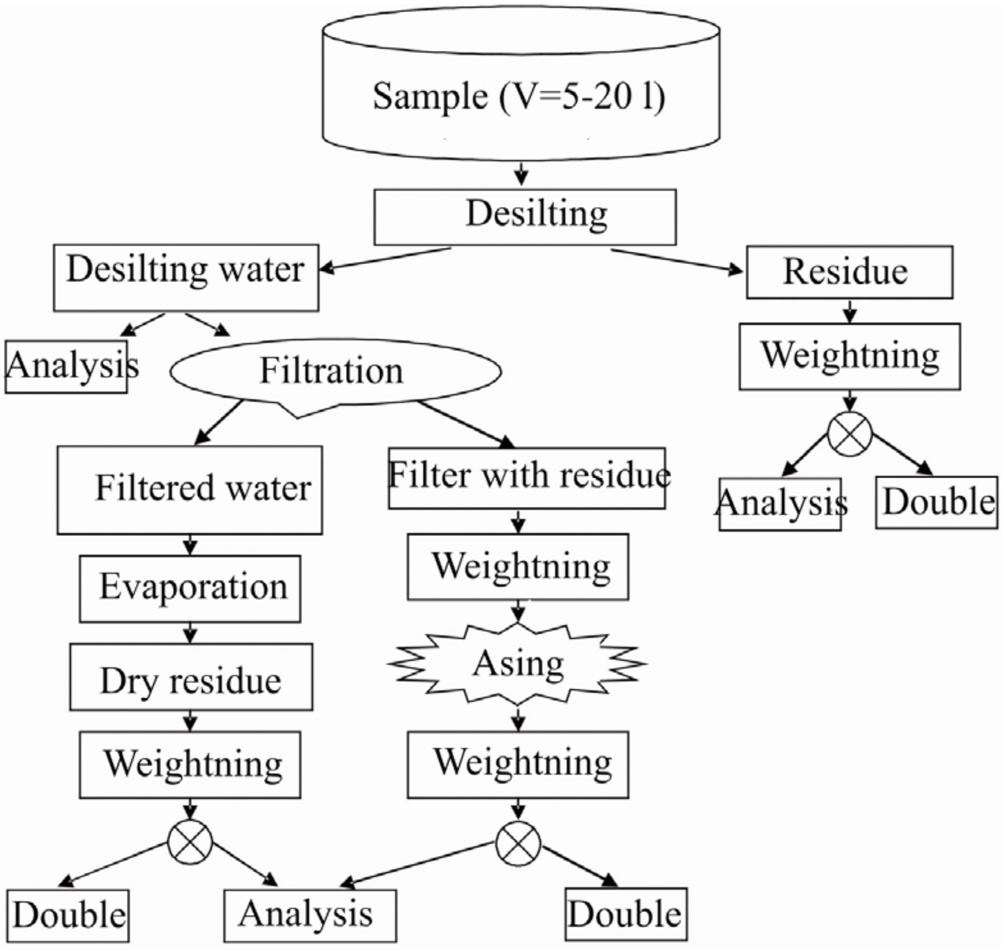


Fig. 3.5.3.1. Scheme of water sample treatment and analysis

When analyses have been carried out the content of investigated pollutants are compared with maximum permissible concentration (MPC), the pollution rate of water body, availability of different kinds of water uses and necessity of enforcement of environmental protection measures are determined.

3.5.4. Bottom sedement sampling and preparation

Bottom sedement is a basic storage tank of the surface water body contaminants.

Hydrolithogeochemical investigations study bottom deposits. They are carried out along with hydrogeochemical investigations. Sampling places are joined with surface water sampling places, and silt-clay deposits are sampled along both valley sides of rivers or directly in the river bed.

Bottom sedement samples are taken from strictly homogeneous bed materials directly down of discharge of sewage. If streams are not large (width –

2–5 m, depth – 0,5–1m), sampling is carried out in line with the area of chosen section of bed. If streams are large, sampling is carried out at water edge; it is desirable that it is in places of visual accumulation of solid materials. On the sections of flows with high content of toxic elements it is possible to organize semistationary and stationary points where monitoring and seasonal observations are carried out. The aim of such kind of investigations is to study flows of chemical elements dispersion in water bodies and streams and to reveal of many years anthropogenic contamination.

Periodicity of bottom deposit sampling – in basic phases of regime of stream. Samples can be taken from different places: from under water, on the steps of bed sandbanks. With the aim of leveling of local variations there are good reasons to compose each sample from several (usually 3-5) individual samples taken near the target observation station. Samples are usually taken along the riverbed or directly at water edge.

Bottom sedements are sampled with a plastic scoop. In the process of sampling from under water the long-handled scoop samplers or standard samplers used in hydrogeology are applied. There are a lot of different devices used for bottom sedement sampling in line with properties of investigated grounds. Subject to investigation tasks and sampling schemes the devices of all systems are used for sampling.

Instruments giving bottom sedement sampling with destratification (bottom samplers (grabs), dredges).

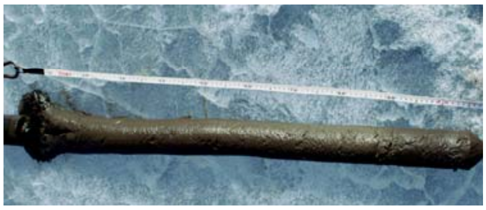
Sampling is carried out with a help of Petersen grab from central sections of stream beds, on the decelerated flow and muck-bottom area. By lifting bottom sampler with the bottom sedement sample the water is poured out and the sample is placed in plastic bag, is labeled, is dried beforehand and is delivered to the laboratory.

Instruments giving bottom sedement sampling without destratification – different configuration tubes, for example, piston corers (fig. 3.5.4.1). Length of the sampled column with bottom sediment is measured, placed in plastic bag. Then it is delivered to the laboratory for analysis.

Weight of the sample is from 1 to 1,5 kg. Bottom sedements are dried when they become air-dry, after that they are treated and analyzed similarly to soil samples.

The content of pesticides, oil products, heavy metals, polycyclic aromatic hydrocarbons is studied in the samples of bottom sedements. Eh, pH, temperature of water and bottom sedements are determined at sampling site.

Piston corers with hydraulic lock



Column of bottom sediment

Fig. 3.5.4.1. Bottom sediment sampling

Revision

1. Give a definition of the term "sanitary protection zone" of surface water.
2. Characterize briefly the program of surface water quality observation subject to the water body category.
3. Give a definition of the term "the section line of the surface water observation site". Tell when one point of observation is placed and when two or more ones are placed.
4. What is "the vertical line" in the section line of the surface water observation station? Tell when one vertical line is placed and when two or more ones are placed.
5. What is "the horizontal line" in the section line of the surface water observation station?
6. Enumerate basic components analyzed in surface waters.
7. How is water sample preparation performed?
8. Formulate the basic requirements to location of bottom sedement sampling places.

Answer the following questions:

1. What types of network stations are used for surface water observation:

a) point;	b) stationary;
c) mobile;	d) proprietory;
e) temporary;	f) geochemical.

2. Match the depth of stream with amount of horizons:

1) to 5:	a) over 5;
2) over 50:	b) 3;
3) over 10:	c) 2;
4) 5–10:	d) 1.

3. Indicators of surface water quality:
a) chemical; b) helminthological;
c) physical; d) physicochemical;
e) sanitary-bacteriological; f) hydrobiological.

4. Surface water sampling is carried out with a help of:
a) plastic buckets; b) metal buckets;
c) bathometers; d) metal bathometers.

5. Bottom sedement sampling is carried out with a help of:
a) plastic buckets; b) Piston corers;
c) dredges; d) bathometers;
e) scoop; f) bottom samplers (grabs).

CONCLUSION

Over the intervening years, while the importance of tracking and assessing chemical residues in the environment still remains, the concept of environmental monitoring has broadened to monitoring and assessment of the endpoints of environmental pollution. Environmental monitoring systems now look far beyond only measuring chemical residues in the environment to identifying and measuring the biological endpoints that more directly reflect the effect of human action rather than just the signature of human action. The importance of and need for integrated environmental monitoring systems is well established (Wiersma, 2004).

In the manual the authors attempted to consider the fundamental principles of the environmental monitoring and its real world application on the base of domestic and foreign experience. The authors pay a great attention to constituent questions needed to get the hang of natural environments monitoring practice: atmospheric air monitoring, snow monitoring, soil monitoring, vegetation monitoring and surface water monitoring.

During the study of "Geoecological environmental monitoring" students can broaden fundamental knowledge and also they can study to apply them for observation, assessment and forecast of anthropogenic changes of ecosystems.

The authors hope that this book will be very useful for university's students, audience of Institute for Continuing Education and experts in environment protection.

Critical comments and suggestions will be accepted gratefully at the following address: 634050, Tomsk, Lenin avenue, 30, Tomsk polytechnic university, Geoecology and Geochemistry Department.

Tel./ Fax: (3822) 418910, E-mail: talovskaj@yandex.ru

REFERENCES

1. Алексеенко В.А. Экологическая геохимия. – М.: Логос, 2000. – 627 с.
2. Берлянд М.Е. Современные проблемы атмосферной диффузии и загрязнение атмосферы. – Л.: Гидрометеоиздат, 1975. – 448 с.
3. Бондарик Г.К., Ярг Л.А. Природно-технические системы и их мониторинг // Инженерная геология. – 1990. № 5. – С. 3–9.
4. Буренков Э.К., Гинзбург Л.Н., Грибанова Н.К. и др. Комплексная эколого-геохимическая оценка техногенного загрязнения окружающей природной среды. – М.: Изд-во «ПРИМА-ПРЕСС», 1997. – 72 с.
5. Василенко В.Н., Назаров И.М. и др. Мониторинг загрязнения снежного покрова. – Л.: Гидрометиоиздат, 1995. – 185 с.
6. Виноградов Б.В., Орлов В.П., Снакин В.В. Биотические критерии выделения зон экологического бедствия России // Известия АН. Сер. географ. – 1993. – № 5.
7. Герасимов И.П. Научные основы современного мониторинга окружающей среды // Изв. АН СССР, сер. Географическая. – 1975. № 3. – С. 13–25.
8. Геохимия окружающей среды / Ю.Е. Сает, Б.А. Ревич, Е.П. Янин и др. – М.: Недра, 1990. – 335 с.
9. Герасимов И.П. Научные основы современного мониторинга окружающей среды // Известия АН СССР. Сер. географ. – 1975. – № 5.
10. Глазовская М.А. Геохимические основы типологии и методики исследований природных ландшафтов. – Смоленск: Изд-во Ойкумена, 2002. – 288с.
11. Глазовская М.А. Геохимия природных и техногенных ландшафтов СССР. – М.: Высш. шк., 1988. – 328 с.
12. Глазовский Н.Ф. Техногенные потоки вещества в биосфере // Добыча полезных ископаемых и геохимия природных экосистем. – М.: Наука, 1982. – С. 86–95.
13. Емельянов А.Г. Комплексный геоэкологический мониторинг. Учебное пособие. – Тверь: Твер. гос. ун-т, 1994. – 88 с.
14. Епишин В.К., Трофимов В.Т. Литомониторинг – система контроля и управления геологической средой // Теоретические основы инж. геол. Социально-экономические аспекты / под ред. акад. Е.М. Сергеева. – М.: Недра, 1985. – С. 243–250.
15. Израэль Ю.А., Гасилина Н.К., Ровинский Ф.Я. Мониторинг загрязнения природной среды. – Л.: Гидрометеоиздат. 1978. – 560 с.

16. Израэль Ю.А. Экология и контроль состояния природной среды. – Л.: Гидрометеоиздат, 1984. – 560 с.

17. Кабата-Пендиас А., Пендиас Х. Микроэлементы в почвах и растениях. – М.: Мир, 1989. – 439 с.

18. Ковалевский А.Л., Ковалевская О.М. О возможности использования полевых методов озоления проб растений при биогеохимических исследованиях / Микроэлементы в Сибири. – Улан-Удэ: Бурят. книж. изд-во, 1967. – Вып. 5. – С. 112–122.

19. Ковалевский А.Л. Биогеохимия растений. – М.: Наука, 1991. – 293 с.

20. Королев В.А. Мониторинг геологической среды: учебник / под редакцией В.Т. Трофимова. – М.: Изд-во МГУ, 1995. – 272 с.

21. Назаров И.М., Фридман Ш.Д. Использование сетевых снегосъемок для изучения загрязнения снежного покрова // Метеорология и гидрология. – 1978. – С. 74–78.

22. Пат. 2229737 Россия, МПК^7 G 01 V 9/00. Способ определения загрязненности снегового покрова техногенными компонентами / Язиков Е.Г., Шатилов А.Ю., Таловская А.В.; заявитель и патентообладатель. Томский политехн. ун-т. – № 2002127851; заявл. 17.10.2002; опубл. 27.05.2004.

23. Пат. 2229738 Россия, МПК^7 G 01 V 9/00. Способ определения загрязненности почвенного покрова техногенными компонентами / Язиков Е.Г., Шатилов А.Ю., Багазий Т.В.; заявитель и патентообладатель. Томский политехн. ун-т. – № 2002127854; заявл. 17.10.2002; опубл. 27.05.2004.

24. Плеханов Г.Ф., Дмитриева Н.Г., Паршина Н.В. Биоиндикационный метод оценки антропогенного загрязнения территории // Охрана природы: сборник статей / под ред. А.Е. Берзина. – Томск: Изд-во НТЛ, 2000. – С. 91–98.

25. Поцелуев А.А., Архангельский В.В. Дистанционные методы исследования окружающей среды. Учебное пособие для вузов. – Томск: STT, 2001. – 184 с.

26. Рихванов Л.П. Общие и региональные проблемы радиоэкологии. – Томск: Изд-во ТПУ, 1997. – 384 с.

27. Тарасов В.В., Тихонова И.О., Кручинина Н.Е. Мониторинг атмосферного воздуха – М.: Изд-во РХТУ им. Д.И. Менделеева, 2000. – 97 с.

28. Шатилов А.Ю. Вещественный состав и геохимическая характеристика пылевых атмосферных выпадений на территории Обского бассейна. Диссер. … канд. геол.-мин. наук. – Томск: ТПУ, 2001. – 205 с.

29. Экологический мониторинг: Состояние окружающей среды Томской области в 2007 году / ред. А.М. Адам / Департамент природ.

ресурсов и охраны окружающей среды Томской обл. и ОГУ «Облкомприрода» адм. Томской области. – Томск: Графика, 2008. – 148 с.

30. Язиков Е.Г., Таловская А.В., Жорняк Л.В. Минералогия техногенных образований: Учеб. пособие. – Томск: Изд-во ТПУ, 2011 – 160 с.

31. Язиков Е.Г., Таловская А.В., Жорняк Л.В. Оценка эколого-геохимического состояния территории г. Томска по данным изучения пылеаэрозолей и почв: монография. – Томск: Изд-во ТПУ, 2010. – 264 с.

32. Жорняк Л.В. Эколого-геохимическая оценка территории г. Томска по данным изучения почв: Автореферат. Дис. … канд. геол.-минерал. наук. – Томск, 2009. – 22 с.

33. Таловская А.В. Оценка эколого-геохимического состояния районов г. Томска по данным изучения пылеаэрозолей: дис. … канд. геол.-минерал. наук: 25.00.36 / Анна Валерьевна Таловская; Том. политехн. ун-т. – Томск, 2008. – 185 с.

34. Environmental Geology. – Berlin: Springer Berlin Heidelberg: Springer Netherlands, 1999. – (Encyclopedia of Earth Science). – URL:http://www.springerlink.de/reference-works.

35. Rikhvanov L.P. Radioactive elements in the environment / L.P. Rikhvanov [and others] // Bulletin of the Tomsk Polytechnic University / Tomsk Polytechnic University (TPU). – Tomsk., 2007. – Vol. 311, № 1. – P. 119–126.

36. Udachin V., Williamson B.J., Purvis O.W., Spiro B., Dubbon W., Brooks S., Coste B., herrington R.J., Mikhailova I. Assessment of environmental impacts of active smelter operations and abandoned mines in Karabash, Ural mountains of Russia // Sustainable development. – 2003. – № 11.

37. Kondratyev K.Ya., Ivlev L.S., Krapivin V.F., Varotsos C.A., Atmospheric aerosol properties: formation, possess and impacts. – Chester: Praxis publishing ltd. – 2006. – 567 p.

38. Conditions of the Natural Environment Components According to Ecological-Geochemical Monitoring and Population Health Data (Tomsk Region) / L.P. Rikhvanov [et al.] // Medical Geology Newsletter. – 2009. – № 14. – P. 31–45.

39. Plakhov A.M. Environmental Safety and Health: Textbook / A.M. Plakhov, A.G. Dashkovsky, V.D. Fedosova. – Tomsk: TPU Press, 2000. – 119 p.

40. Fried J.I. Groundwater pollution: theory, methodology, modelling and practical rules. Oxford – New York, 1975. – 330 p.

41. Sharma B. K. Air Pollution / B. K. Sharma. – 3-rd Ed. – India: Krishna Prakashan Media Ltd., 1999. – 207 p.

42. Lollar Barbara Sherwood. Environmental Geochemistry. Vol. 9: Treatise on Geochemistry / B.S. Lollar. – Amsterdam: Elsevier, 2005. – 630 p.

43. Glasson John. Introduction to Environmental Impact Assessment / J. Glasson, R. Therivel, A. Chadwick. – 2nd ed. – Oxford: UCL Press, 1999. – 496 p.

44. Katyal Timy. Environmental Pollution / T. Katyal, P.M. Satake, R. Kumar. – India: Anmol Publications PVT.LTD, 2001. – 302 p.

45. Plasad M.N.V. Trace Elements in the Environment. Biogeochemistry, Biotechnology, and Bioremediation / M.N.V. Plasad, K.S. Sajwan, R. Naidu. – Boca Raton: Taylor & Francis, 2006. – 726 p.

46. Kabata-Pendias, Alina. Trace Elements in Soils and Plants / A. Kabata-Pendias H. Pendias. – Third Edition. – Boca Raton: CRC Press, 2001.

47. Dara S.S. A Textbook of Environmental Chemistry and Pollution Control – 4-th ed. – Delhi: S. Chand & Company LTD, 2001. – 329 p.

48. Guselnikov M.E., Stroinova V.N. Ecological Monitoring: Textbook. – Tomsk: TPU Press, 2000. – 76 p.

49. Elsom D.M. Atmospheric Pollution: A Global Problem (2nd edition). – Oxford: Blackwell Publishers, 1995. – 422 p.

50. ISO 14031. Environmental management – Environmental performance evaluation – Guidelines.

51. Young J. Kim, Ulrich Platt, Man Bock Gu, Hitoshi Iwahashi. Atmospheric and Biological environmental monitoring. – Springer, 2009. – 308 p.

52. Wood C. Environmental impact assessment. – Longman, 1995.

53. Gul Asiye Aycik. New Techniques for the Detection of Nuclear and Radioactive Agents. – Springer, 2008. – 345 p.

54. Awange J.L. Environmental Monitoring using GNSS. – Springer, 2012. – 380 p.

55. Sharma B.K. An introduction to Environmental Pollution. – India: Krishna Prakashan Media LTD, 2001.

56. Graund water monitor // Ground Water Monitor. – 1987. – Vol. 3. – № 3. – P. 17-24.

57. Kist A.A., Zhuk L.I. Human haiz composition and the problems of global ecology.-Tashkent: Preprint R-3-509, 1991. – 117 p.

58. Munn R.G. Global environmental monitoring system (GEMS). Action plan for Phase // SCOPE. Rep. 3. Toronto, 1973. – P. 37–42.

59. Weiss H.V., Herron M.M., Langway C.C. Natural environment of element in snow. – Nature, 1978. – Vol. 274. – № 5669. – P. 352–353.

60. Environmental monitoring / Edited by Wiersma G.B. – Boca Raton London New York Washington: CRC PRESS, 2004. – 767 p.

Нормативно-методические издания

61. Критерии оценки экологической обстановки территорий для выявления зон чрезвычайной экологической ситуации и зон экологического бедствия (утвержд. Минприроды РФ 30 ноября 1992г). – М., 1992. – 58 с.

62. Методические указания по принципам организации системы наблюдений и контроля за качеством воды водоемов и водотоков на сети Госкомгидромета в рамках ОГСНК. – Л.: Гидрометеоиздат, 1984. – 40 с.

63. Методические рекомендации по геохимической оценке загрязнения территории городов химическими элементами. – М.: ИМГРЭ, 1982. – 112 с.

64. Методические рекомендации по геохимической оценки источников загрязнения окружающей среды. – М.: ИМГРЭ, 1982. – 66 с.

65. Методические рекомендации по оценке степени загрязнения атмосферного воздуха населенных пунктов металлами по их содержанию в снежном покрове и почве. – М.: Минздрав, 1990.

66. Перечень ПДК и ОБУВ вредных веществ для воды рыбохозяйственных водоемов / Комитет РФ по рыболовству. – М.: Мединор, 1995. – 222 с.

67. Перечень ПДК и ориентировочно-допустимых количеств (ОДК) химических веществ в почве. – М., 1993. – 14 с.

68. Предельно допустимые концентрации (ПДК) и ориентировочные безопасные уровни воздействия (ОБУВ) вредных веществ в воде водных объектов хозяйственно-питьевого и культурно-бытового водопользования. – М., 1983, № 2932-83 от 24.10.83.

69. Руководство по контролю загрязнения атмосферы. РД 52.04.186-89. – М.: Госкомгидромет, 1991. – 693 с.

70. Руководство по химическому анализу поверхностных вод суши. – Л.: Гидрометеоиздат, 1977. – 540 с.

71. Санитарные правила и нормы охраны поверхностных вод от загрязнения. – М., 1988, № 4630 от 4.07.88.

72. Санитарные нормы предельно допустимого содержания вредных веществ в воде водных объектов хозяйственно-питьевого и культурно-бытового водопользования. – М., 1986, СанПиН № 42-121-4130-86 от 4.07.86.

73. Федеральный Закон от 10.01.2002 № 7-ФЗ «Об охране окружающей среды»

74. Федеральный Закон от 18.11.95 № 167-ФЗ «Водный кодекс Российской Федерации»

Russian state standard (ГОСТ)

75. ГОСТ 17.1.3.06–82. Охрана природы. Гидросфера. Общие требования к охране подземных вод.
76. ГОСТ 17.2.1.03–84. Охрана природы. Атмосфера. Термины и определения контроля загрязнения.
77. ГОСТ 17.2.6.01–86. Охрана природы. Атмосфера. Приборы для отбора проб воздуха населенных пунктов. Общие технические требования.
78. ГОСТ 17.2.2.01–86. Охрана природы. Атмосфера. Правила контроля качества воздуха населенных пунктов.
79. ГОСТ 17.2.4.02–81. Охрана природы. Атмосфера. Общие требования к методам определения загрязняющих веществ.
80. ГОСТ 2874–82. Вода питьевая.
81. ГОСТы: 3351–74; 4192–82; 4011–72; 4151–72, 18826–73, 4389–72, 18164–72, 4245–72, 18165–81, 18294–89, 4974–72, 4388–72, 18308–72, 4152–89, 18293–72, 23950–88, 18309–72, 4386–89. Вода питьевая: сборник. Методы анализа. – М., 1984.
82. ГОСТ 27384–87. Вода. Нормы погрешности измерений показателей состава и свойств.
83. ГОСТ 27065–86. Качество вод. Термины и определения.
84. ГОСТ 17.1.1.02–77. Охрана природы. Гидросфера. Классификация водных объектов.
85. ГОСТ 17.1.1.03–78. Охрана природы. Гидросфера. Классификация водопользования.
86. ГОСТ 17.1.1.04–80. Охрана природы. Гидросфера. Классификация вод по целям водопользования.
87. ГОСТ 17.1.5.01–80. Охрана природы. Гидросфера. Общие требования к отбору проб донных отложений водных объектов для анализа на загрязнённость.
88. ГОСТ 17.1.5.05–85. Охрана природы. Гидросфера. Общие требования к отбору проб поверхностных и морских вод, льда и атмосферных осадков.
89. ГОСТ 17.1.3.1–86. Охрана природы. Гидросфера. Общие требования к охране поверхностных вод от загрязнения.
90. ГОСТ 17.8.1.01–86. Охрана природы. Ландшафты. Термины и определения.
91. ГОСТ 17.8.1.02–88. Охрана природы. Ландшафты. Классификация.
92. ГОСТ 17.0.0.02–79. Охрана природы. Метрологическое обеспечение контроля загрязнённости атмосферы, поверхностных вод и почвы. Основные понятия.

93. ГОСТ 17.4.1.02–83. Охрана природы. Почвы. Классификация химических веществ для контроля загрязнения.

94. ГОСТ 17.4.4.02–84. Охрана природы. Почвы. Методы отбора и подготовки проб для химического, бактериологического, гельминтологического анализа.

95. ГОСТ 17.4.2–01–81. Охрана природы. Почвы. Номенклатура показателей санитарного состояния.

96. ГОСТ 17.4.3.01–83 (ст. СЭВ 3847–82). Охрана природы. Почвы. Общие требования к охране почв.

97. ГОСТ 28168–89. Почвы. Отбор проб.

98. ГОСТ 5681–84. Полевые исследования почвы. Порядок и способы определения работ. Основные требования к результатам.

99. Ориентировочные безопасные уровни воздействия (ОБУВ) загрязняющих веществ в атмосферном воздухе населённых мест № 2947–83 от 20.12.83 (№ 4414-87 от 28.08.87).

100. Предельно допустимые концентрации (ПДК) загрязняющих веществ в атмосферном воздухе населённых мест. № 3081-84 от 27.08.84.

101. Предельно-допустимые концентрации (ПДК) загрязняющих вещетсв в атмосферном воздухе населённых мест. Дополнение № 1 к списку № 3285-85 от 8.05.85.

102. Предельно допустимые концентрации (ПДК) загрязняющих веществ в атмосферном воздухе населённых мест. Дополнение № 2 к списку № 4256-87 от 3.02.87.

103. Предельно допустимые концентрации химических веществ в почве (ПДК). Список № 4 2546-82 от 30.04.82.

104. Предельно допустимые концентрации химических веществ в почве (ПДК) № 3210 от 1.02.85.

105. Предельно допустимые концентрации химических веществ в почве (ПДК). Санитарные правила и нормы № 128-4275-87.

Journals

Environmental monitoring and assessment
Environmental science and pollution research
Environmental and Ecological Statistics
Геохимия.
Геоэкология. Инженерная экология. Гидрогеология. Геокриология.
Горный журнал.
Записки Всероссийского минералогического общества.
Сибирский экологический журнал.

Экология.

Экологический мониторинг. Состояние окружающей природной среды Томской области. – Ежегодный обзор Управления охраны окружающей среды и ОГУ «Облкомприрода» Администрации Томской области.

***Internet*-resources:**

1. http://www.ecology.tomsk.ru/ – Tomsk ecological page
2. http://www.meteo.ru/ – Russia hydrometeorological data
3. www.tgm.ru – ОАО «Tomskgeomonitoring», Tomsk.
4. http://www.geomonitoring.ru/ – data of state monitoring system of subsoil
5. http://www.green.tsu.ru/ – ОГУ «Oblcompriroda» (г. Томск)
6. http://portal.main.tpu.ru/SHARED/t/TALOVSKAYA – print clone of lectures
7. http://www.springerlink.de/books – Springer – full-text books published from 2000 to present.
8. http://www.lib.tpu.ru/full_text.xml?lang=ru#textbooks – full-text and bibliographic database from scientific-technical library site of TPU. http://www.wmo.int/pages/index_ru.html – Global meteorological organization
9. http://gaw.empa.ch/gawsis – Global atmospheric Watch
10. http://www.art.man.ac.uk/eia/eiac.htm – Центр экологической оценки Манчестерского университета (Великобритания).
11. http://www.ecoline.ru/mc – неправительственная организация «Эколайн» (г. Москва, Россия)
12. http://www.spotimage.fr; www.spot.com – SPOT Image, Франция (цифровая космическая съемка с французского спутника SPOT).
13. http://www.spaceimaging.com; http://www.erimage.it – Space Imaging, США (космосъемки со спутников США «Landsat» и EURIMAGE).
14. Site web de la commission locale de l’eau Orge Yvette: http://pagespersoorange.fr/cle.orge-yvette/
15. Site web du ministère de l’Ecologie, de l’Energie, du Développement durable et de la Mer: http://www.developpement-durable.gouv.fr/
16. Site web des outils de gestion intégrée de l’eau GEST’EAU www.gesteau.eaufrance.fr
17. Site web de l’Association pour un contrat mondial de l’eau http://www.acme-eau.org/
18. http://www.ifremer.fr/delcc/cycleau/reglementation/seqeau.htm. Le Système d'Evaluation de la Qualité des cours d'eau (SEQ-Eau).
19. http://eqb-dqe.cciw.ca/eman/program/about.html – Environment Canada. 2002. The ecological monitoring and assessment network: all about EMAN, in Information for Improving Europe’s Environment.
20. http://org.eea.int/documents/brochure/brochure reason.html – European Environmental Agency. 1999. Conceptual Framework: How We Reason.

Educational Edition

Национальный исследовательский
Томский политехнический университет

ЯЗИКОВ Егор Григорьевич
ТАЛОВСКАЯ Анна Валерьевна
НАДЕИНА Луиза Васильевна

ГЕОЭКОЛОГИЧЕСКИЙ МОНИТОРИНГ

Учебное пособие

Издательство Томского политехнического университета, 2013

На английском языке

Published in author's version

Science Editor
Doctor of Geological and Mineralogical Sciences, Professor
S.I. Arbuzov

Typesetting *V.P. Arshinova*
Cover design *A.I. Sidorenko*

Printed in the TPU Publishing House in full accordance
with the quality of the given make up page

Signed for the press 26.03.2013. Format 60x84/16. Paper "Snegurochka".
Print XEROX. Arbitrary printer's sheet 7,62. Publisher's signature 6,89.
Order 286-13. Size of print run 70.

Tomsk Polytechnic University
Quality management system
of Tomsk Polytechnic University was certified by
NATIONAL QUALITY ASSURANCE on BS EN ISO 9001:2008

TPU PUBLISHING HOUSE. 30, Lenina Ave, Tomsk, 634050, Russia
Tel/fax: +7 (3822) 56-35-35, www.tpu.ru