

The SB RAS Interdisciplinary Project “Ecological Problems of Siberian Cities”

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Information on the SB RAS Interdisciplinary Project “Ecological Problems of Siberian Cities” is presented. It concerns the multidisciplinary research into fundamental aspects of transformations of hydrodynamics and composition of the town atmosphere and their influence on environmental quality, the human life and health. The motivation and results of the first stage of the research are briefly described.

The Project “Ecological Problems of Siberian Cities” has won in the competition of interdisciplinary projects announced by the Presidium of SB RAS at the end of 2002. Now it is drawing towards completion. The project incorporates the efforts of 14 scientific institutes of SB RAS (Institute of Computational Mathematics and Mathematical Geophysics, Institute of Atmospheric Optics, Institute of Monitoring of Climatic and Ecological Systems, Institute of Solar-Terrestrial Physics, Institute of Theoretical and Applied Mechanics, Institute of Chemical Kinetics and Combustion, Institute of Taxonomy and Ecology of Animals, Institute of Applied Astronomy, Institute of Chemical Biology and Fundamental Medicine, Central Siberian Botanical Garden, Siberian Center for Environmental Research and Training, Baikal Institute of Nature Management) and other organizations and institutions (Central Design Office of SB RAS, State Scientific Center of Virology and Biotechnology “Vector,” West-Siberian Satellite Data Receiving and Processing Center).

The major objective of this project is to carry out interdisciplinary scientific research aimed at solution of basic problems concerning the effect of cities on hydrothermodynamic properties and composition of the atmosphere and, consequently, on the human health, life quality, and the environment.

Siberian cities are characterized by a significant dependence of the atmospheric quality on climatic conditions. For more than a half of a year, a stable atmospheric stratification with temperature inversions dominates in Siberia, and this favors accumulation of pollutants of various origins in the lower atmosphere, just where ecosystems function and people live.

In addition to severe climate, the effect of anthropogenic factors on the environment and inhabitants becomes increasingly pronounced in modern industrial cities. This effect manifests itself in the pollution of the environment, changing Earth's

surface characteristics and hydrothermodynamic conditions of the atmosphere, etc. Specific mesoclimates, favoring the accumulation of pollutants, are created in cities, and urbanoses are formed in them under extreme conditions, not foreseen by evolution. So, these cenoses form absolutely new and poorly studied type of ecosystems. Natural and anthropogenic systems (power and industrial objects, traffic, and others) are in a very close interaction here. There are serious contradictions between the increasing chemicalization of all industrial branches and the low general chemical erudition even at the level of making crucial decisions. For example, incomplete technologies without the final stage of waste utilization are still implemented in practice. Therefore, there is a high potential risk of anthropogenic catastrophes, which, in turn, may provoke ecological disasters through emissions of heat, moisture, and toxicants.

It should be also kept in mind that cities are not closed systems. They can both spread the pollutants to the ambient territories and receive them from without.

All these issues are connected with ecological safety and the quality of life. The close relation between the human environment and the human health, efficiency, and life span is now beyond doubts.

General worsening of ecological situation in Siberian cities contributes to accumulation of toxicants in human organs and tissues, which affects the functioning of the organism as a whole and leads to metabolic disorders. As a result, exotoxicosis is accompanied by the toxicosis caused by the internal metabolic disturbance (endotoxicosis). Compensatory mechanisms break, in particular, foreign products of protein proteolysis are accumulated, leading to disturbances in the human immune system and an increased risk of development of various pathological processes.

The deficit of basic medical knowledge on endotoxigenesis and the lack of deep understanding into actual biochemical and physiological processes prevent the real-time expert diagnosis of pathological states caused by the increased anthropogenic load.

The normative approach to the assessment of ecological risk for all types of industry, which is used everywhere in Russia, is out of date and does not permit the solution of the major strategic problem – prevention of ecologically dangerous situations and mitigation of their possible consequences. One of the causes is a lag of basic scientific knowledge in the field of ecological chemistry and related fields behind urgent ecological problems to be solved as soon as possible. Many basic and applied investigations carried out by Russian scientists in particular fields of knowledge fall in the course of international tendencies and are highly competitive with foreign investigations in the level, approaches, and classes of solved problems. Unfortunately, they are characterized by the deficit of interdisciplinary interactions needed for the integrated solution of such problems.

An example of this thesis can be a typical recent situation in Novosibirsk city connected with the project of a household waste combustion plant to be built in the dwelling zone. Ecological aspects of this project were not deep-laid. In other cities, there appear both local ecological problems and typical ones in common. For example, situations with increased ozone concentrations take place in Tomsk. This alarming fact calls for specialized investigation. The Academy towns in Novosibirsk, Krasnoyarsk, and Irkutsk are located in zones of influence of mesoclimates, caused by interaction of water objects with the urban heat island, which increases the vulnerability of the atmosphere to pollution. These aspects also call for additional investigations when planning the industrial activity. Cities of Western Siberia are situated in the zone of influence of vast wetland territories of oil-and-gas bearing provinces, which emit methane into the atmosphere. These natural emissions are accompanied by anthropogenic ones, caused by hydrocarbon production and processing activities. It is known that secondary products of methane transformation include some highly toxic compounds, such as formaldehyde, formic acid, and others. It is still unclear how dangerous is this situation for Siberian inhabitants.

The Siberian Branch of the Russian Academy of Sciences incorporates highly qualified specialists, who can, united, advance significantly basic investigations and simultaneously take part in solving crucial problems of Siberian cities. The concentration of scientific resources in the SB RAS institutes and regional universities also creates a unique possibility of thorough investigation of environmental factors affecting urbanized ecosystems, in particular, their flora and fauna components. Now there is an urgent need in gaining the experience in interdisciplinary ecological expertises in order to mitigate the inevitable negative consequences of anthropogenic effects. Therefore, one of the major tasks of this project is to

organize a highly professional team, capable of considering the whole set of problems in totality.

According to ideas of participants of this project, the ecological expertise must be based on the materials and conclusions drawn from the results of mathematical simulation of the environmental quality, carried out with the maximal usage of all available information about actual processes. The information can be obtained from combined monitoring of the atmosphere with the use of ground-based, airborne, and spaceborne observation facilities. Further consideration should be performed based on this information and actual data about responses of bio- and ecosystems to the anthropogenic impact. And, finally, the existing tendencies in the health of the population of the region under study should be taken into account as well. An emphasis in this project is on a search of criteria and approaches to separation of situations and objects characterized by the increased risk/vulnerability to harmful effects, as well as on a search of indicators characterizing the environmental state.

This project is in progress for more than two years. For this time, interesting basic results, which are, at the same time, directly related to problems of particular Siberian cities, have been obtained. We mention only some of them.

The development of the concept of ecological expertise has been started. The expertise involves several stages: scenario estimates of changes in the quality of the atmosphere based on numerical simulation using the data of ground-based, airborne, and spaceborne monitoring; comparative analysis and generalization of all available experimental data about the state of bio- and ecosystems and human health in the regions under study; assessment of tendencies of possible changes upon the change of the anthropogenic impact, separation of situations characterized by the increased risk/vulnerability to this impact.

Actual data have been acquired in all sections of the project, which characterize the current state of the environment with the emphasis on the indicators of changes in the environment and human health in Siberian cities. The information database for integration of knowledge is under development.

Numerous observations of the atmospheric quality and specific pollutants in Siberian cities are carried out with stationary observation systems, a vehicular measuring system, and an aircraft laboratory.

A set of characteristic and extreme situations of atmospheric and surface pollution in the cities has been separated from the data of spaceborne monitoring and analyzed.

Priority pollutants of the atmosphere, soil, and plants in the Novosibirsk Region are determined. A tentative zoning of the Novosibirsk territory is performed in accordance with the pollution of soil, the state of lichen and biotopes. In all elements of bio- and ecosystems, indicators of depression caused by the anthropogenic impact have been revealed.

Specific conditions of Siberian cities, which serve a dynamic background for the processes of transformation, transport, and deposition of pollutants,

have been analyzed from the climatic-ecological point of view. The data for Novosibirsk, Tomsk, Irkutsk, Ulan-Ude, and Norilsk cities have been analyzed to some or other degree.

A new version of a suit of models, oriented at solution of problems of this project, has been developed; a series of scenario calculations were conducted in order to evaluate the scales of ecological interactions of Siberian cities as sources and recipients of anthropogenic pollutants. The maps of mutual risks/vulnerability of the cities are drawn for typical climatic situations.

The development of the models and methods for studying the processes of atmospheric transformation of pollutants and identification of toxicants under different conditions of chemical reactions are being continued. A scheme of elementary reactions responsible for photochemical transformations of acetaldehyde is worked out.

A cycle of investigations into basic and applied medicine has been carried out in order to reveal human organism reactions to adverse effects. Methodical

approaches to actual constructing of the situational ecological-epidemiological pattern of urbanized territories are coming into development. Analysis of the information obtained has shown that epidemiological inhomogeneity of the Novosibirsk Region is caused, to a high extent, by the current ecological situation. The structure of cancer morbidity in different parts of the Novosibirsk Region for the last three years has been studied. The assessment of the state of health and morbidity in different parts of the Novosibirsk Region allowed us to separate groups of patients with diseases, which can be initiated by the presence of acetaldehyde and products of its secondary transformations in air.

These are the intermediate results of the project. It should be noted that municipal administrations of Siberian cities show interest to the results of these investigations. This allows us to hope that the results of this work will be usable in planning the environmental activities, conducting ecological expertises, and constructing the strategies of economical development with allowance for ecological safety.