PROTECTION OF THE OCEANS AND THEIR LIVING RESOURCES

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Contents

Summary

The prominent role of the oceans in the existence of humankind is discussed. Intensive utilization of ocean resources, their significance in the economic activities of humanity and increasing anthropogenic impacts, are described. Particular attention is paid to the internal and external seas of Russia, whose territory is washed by twelve seas belonging to the water bodies of three oceans, namely the Atlantic (Baltic Sea, Black Sea, and the Sea of Azov), the Arctic (Barents Sea, White Sea, Laptev Sea, East Siberian Sea, and Chukchi Sea) and the Pacific (Bering Sea, Sea of Okhotsk, and Sea of Japan). The Caspian Sea is isolated and not considered in this chapter. The sources of pollution of the Russian seas are discussed and the important role of river runoff and atmospheric fluxes in the chemical pollution of these seas is shown. Emphasis is placed on the most dangerous pollutants, their distribution in different seas and their property of accumulation in marine ecosystem components. The condition of the Russian seas is discussed and the negative ecological consequences of chemical pollution in different seas are shown. Discussion of the strategy for oceans and protection of their living resources occupies an important place in the article. Future tasks of ecological

investigation and monitoring of the marine environment are presented.

1. Introduction

At the end of the twentieth century environmental pollution has become one of the most serious and significant problems facing the world. Increase in pollution is closely connected with the development of industrial production.

Anthropogenic activity has a pronounced effect on the input of numerous chemical and radioactive contaminants to the marine environment. Millions of tons of oil and thousands of tons of chlorinated hydrocarbons enter the World Ocean every year from different sources, including precipitation from the atmosphere. Anthropogenic components of the fluxes of certain contaminants (lead, oil, mercury, etc.) released into the World Ocean are now comparable to the natural component or even exceed it. Local pollution and its adverse effect become global in the World Ocean. More and more new contaminants (toxaphenes, benzodioxines, etc.), which are very hazardous to life, have now become widespread through the World Ocean.

The World Ocean covers about 71% of the Earth's surface (361 million of the Earth's 510 million km^2). The mean depth of the World Ocean is 3795 m and some depths are 7000 to 11 000 m.

The World Ocean accounts for 94% of the hydrosphere, the rest being ice, river and lake water, and atmospheric moisture.

The word "ocean" originates from the ancient Greek word "okeanos," which means "the great river that washes the land". The term "the World Ocean" was first mentioned by the Russian oceanographer U.M. Shokalski, and is commonly used for the whole water body of our planet.

The World Ocean's control over the earth's vital processes plays an important role in the existence of every living thing on the planet. Ocean phytoplankton provides 50 to 70% of the total oxygen volume produced by living plants, and sea-air interaction is a vital factor of weather and climate formation.

All seas, straits and bays are regarded as parts of the World Ocean. Each sea has its own specific regime created by local conditions and the degree of water exchange with the neighboring ocean. While all the seas are in contact with the ocean, at the same time they are separated from it by a variable pattern of coastal configuration and often a series of islands. Hence, each sea is a natural regional object.

In this chapter we focus primarily on the internal and external seas of Russia, the territory of which is washed by three oceans and twelve seas: the Atlantic Ocean (including the Baltic Sea, the Black Sea and Sea of Azov), the Arctic Ocean (the Barents Sea, the White Sea, the Laptev Sea, East Siberian Sea and Chukchi Sea) and the Pacific Ocean (the Bering Sea, the Sea of Okhotsk, and the Sea of Japan). (Being strictly a lake, we are not including the Caspian Sea.)

We should mention that the common area of seas washing the coast of Russia (the land area of which is 17 095 000 km^2), reaches 10 975 000 km^2. The length of the Russian marine coastline is about 38 000 km while that of the land border is only 20 322 km. The key factor in the fisheries of Russia is the efficiency of fishing in the seas adjacent to its coasts. Fish production is affected to a lesser extent by the operations of long-distance fleet on the high seas of the World Ocean, and in the coastal waters of other states. In recent years, Russia's fishing efforts have become more concentrated in the Barents, Bering and Okhotsk Seas, and the biggest mariculture (aquaculture) projects are in the White Sea.

The greater part of the recent annual Russian marine fish catch of 3.5 to 4.2 million tons is from the Arctic-boreal or Northern boreal regions of the North-East Atlantic and North-West Pacific, predominantly the Barents and Bering Seas, the Sea of Okhotsk, and the adjoining regions; these yield about 80% of the entire Russian catch. It is here in the high latitudes of the World Ocean that the main enterprises of Russian fisheries are concentrated.

Preservation and sustainable development of these natural resources is of extreme importance to human society. The solution of this problem must be based on sound scientific knowledge and a clear strategy directed at protection of the seas and its living resources as well as the development of nature protection and conservation activities.

2. Russian Seas of the Arctic Ocean

The Arctic Ocean and adjacent seas have a pronounced effect on the state of the Earth's climate and play a decisive role in many global processes. Arctic seas regulate the global carbon cycle, being an important carbon dioxide (CO_2) source in winter and a sink of CO_2 flux in summer. Recent investigations have shown that the Arctic is playing an important role in the removal of atmospheric CO_2, and should continue to do so.

Arctic seas have a profound impact on many large-scale oceanographic processes. They are a zone of deep-ocean water formation, and they determine to a great extent the global hydrological cycle on the planet and atmospheric heat absorption. Some Arctic seas and almost all shelf ecosystems in the Arctic are characterized by high biological productivity (the Arctic shelf accounts for more than 25% of the entire World Ocean shelf). The primary production of the Russian Arctic Seas reaches the following values: the White Sea—2.3 million tons of organic carbon (C), the Barents Sea—55 million tons C, the Kara Sea—20 million tons C, the Laptev and East Siberian Seas—10 to 15 million tons C, and the Chukchi Sea—42 million tons C. It is useful to note that the primary production of the World Ocean is of the order 90 to 100 billion tons C. There is a long history of fisheries in the White and Barents Seas exploiting the rich reserves of many valuable fish species. During 1991–1995 the total catch of marine fisheries in the Barents Sea was from 261 000 to 552 000 tons (about 20% of Russia's total catch). It is worth noting that the Barents Sea belongs to the category of highly productive seas. It is subject to considerable anthropogenic impact including active extractions of biological resources. Marine ecosystem have to adapt to major restructuring of food chains, changes in species diversity and general decrease in biological productivity.

Problems of environmental protection relating to Arctic and sub-Arctic marine ecosystems become increasingly important with the intensification of economic activities in the Russian Arctic and the high sensitivity of these ecosystems to anthropogenic impacts. The instability and vulnerability of Arctic seas are related to environmental factors such as: the long light period in summer and diminished solar radiation in winter; substantial freeze-up periods and thick ice cover; low water temperature; short food chains and simple food webs; low species diversity; and widespread long-living organisms with a high lipid content (in which the most dangerous toxic compounds accumulate). The low water temperature results in much slower rates of microbial degradation in the Arctic seas as compared with seas in moderate latitudes. This results in greater accumulation of toxics in various components of the marine ecosystems.

2.1. Sources and Transport of Pollutants

As a consequence of human activities, a tremendous quantity of pollutants enters the Arctic Ocean through direct dumping of waste from industrial, municipal, and agricultural enterprises situated on the coast, burial of toxic material, accidents, land runoff, operation of transport facilities of all kinds (marine and river craft, aviation, timber rafting, road, and pipe-line transport), mineral extraction, pollutant transport by the water masses of the Arctic seas, river runoff and through the atmosphere (a short description of hazardous pollutants is given below in section 2.2).

Many contaminants, including chlorinated hydrocarbons and benzo(a)pyrene, are found in the atmosphere above the Arctic seas. At the same time, data on concentrations of contaminants in the atmosphere above the seas of the Russian Arctic are rather sparse, although air samples are collected by the Russian background monitoring station network—Roshydromet, the Russian Federal Service for Hydrometeorology and Environmental Monitoring—as well as during special expeditions.

Rather high concentrations of certain toxicants have been discovered in the air above the industrial centers of the Russian Arctic. For example, above the industrial centers of the Murmansk Region, the concentration of benzo(a)pyrene (BP) varied between 0.0011 and 0.0095 mg/m^3. Above the Arkhangelsk Region, Komi Republic, Jakutia, and Chukchi Autonomous Area the equivalent figures were 0.001 to 0.011, 0.001 to 0.006, 0.001 to 0.010, and 0.0012 to 0.002 mg/m^3, respectively. It should be noted that BP possesses toxic, mutagenic, and carcinogenic properties. Besides, BP circulates actively within Arctic ecosystems and accumulates in marine biota, including organisms of commercial value.

The present state of the Arctic Ocean depends to a large extent on the large river input, which is equivalent to about 10% of the total global runoff. Important quantities of chemically reactive and biogenic material may be transported by the rivers. Owing to the huge catchment area (12 819 000 km^2, i.e. 75% of the entire area of Russia) and large water content (70% of the total river runoff), the total flux of various pollutants entering the Arctic Ocean in river runoff is very high This includes 65 to 75% of the organic matter, nitrogen, phosphorus, iron, and silicon compounds, 91% of the petroleum pollution, 95% of HCH isomers, 51% of DDT and 18% of the DDE pollution produced by the Russian Federation.

The rivers of the Russian Arctic can be arranged in descending order of the amounts of organochlorine hydrocarbons (HCH, DDT, DDE) entering the Arctic Ocean, as follows: the Yenisei (the Kara Sea)—the Ob (the Kara Sea)—the Pechora (the Barents Sea)—the Taz (the Kara Sea)—the Mezen (the White Sea)—the Onega (the White Sea)—the Northern Dvina (the White Sea)—the Anabar (the Laptev Sea)—the Kola (the Barents Sea)—the Olenek (the Laptev Sea)—the Lena (the Laptev Sea)—the Kolyma (the East Siberian Sea).

The rivers of the Russian Arctic can also be arranged in descending order of petroleum input into the seas of the Arctic Ocean as follows: the Ob (the Kara Sea)—the Yenisei (the Kara Sea)—the Anabar (the Laptev Sea)—the Lena (the Laptev Sea)—the Taz (the Kara Sea)—the Pur (the Kara Sea)—the Olenek (the Laptev Sea)—the Kolyma (the East Siberian Sea)—the Anadyr (the Bering Sea)—the Pechora (the Barents Sea)—the Northern Dvina (the White Sea)—the Indigirka (the East Siberian Sea)—the Onega (the White Sea)—the Mezen (the White Sea)—the Kola (the Barents Sea).

In recent years the output of petroleum hydrocarbons has increased into every sea of the Russian Arctic. The most significant increase of output of petroleum hydrocarbons in river flow was observed in the Laptev Sea (10 times). These changes were caused by a sharp increase in petroleum hydrocarbon contamination in the rivers Lena and Anabar. It is also important to note that prospecting and exploration for oil in the shelf zone of Arctic seas leads to further significant contamination of the coastal sea areas by petroleum hydrocarbons.

The most productive coastal ecosystems of the Barents Sea, along with pollution sources inherent in all the Arctic seas, are under the influence of such specific sources as the Gulf Stream, which shows up most vividly on the eastern shores and the islands. The flotsam debris brought by the Gulf Stream lies in a strip 5 to 10 m wide along the strandline, on a coastline more than 4000 km long.

2.2. Chemical Pollution

The character of marine environmental pollution is peculiar for each of the Arctic seas and it depends on the degree of anthropogenic stress and the specificity of contamination sources. Estimation of the state and level of degradation of the marine ecosystems is based on the results of study and joint analysis of the following interconnected problems:

- study of chemical pollution of the marine environment,
- study of the ecological consequences of anthropogenic impacts on the marine environment,
- study of the natural processes that degrade pollutants, and
- determination of the stability of the marine ecosystem to anthropogenic impact.

There have recently been many discoveries regarding various aspects of the influence of anthropogenic factors on high latitude marine ecosystems—including the increase of levels of chemical contamination in coastal waters and the distribution of low-level contamination by stable chemical compounds in open waters. Both intensive contamination and factors of low intensity pose threats to ecological well being.

Looking at the ecological situation in the shelf part of Russian Arctic seas, one can arrange the marine pollutants in the following order (by degree of expected and observed effects):

- petroleum hydrocarbons,
- organic (primarily chlorinated) contaminants , and
- heavy metals

Petroleum hydrocarbons. Petroleum and its hydrocarbons pose the major threat for the Arctic seas. The highest concentrations of petroleum hydrocarbons (PH) were found in Kola bay of the Barents Sea, and in the estuaries of certain rivers (see Table 1).

	Barents Sea (Kola Bay)	**Barents Sea**	**White Sea**	**Kara Sea**	**Laptev Sea**	**East Siberian Sea**	**Chukchi Sea**	**Chukchi Sea (open)**	**Bering Sea (open)**
DDT (ng/l)	0.25	0.01	0.19	1.3	0.2	1.5	1.06	0.12	0.19
HCH (ng/l)	7.2	4.2	3.6	1.7	2.1	2.3	2.2	2.1	2.2
Cd (μg/l)		0.28	0.07	0.3	0.04	0.03	0.05	0.05	0.07
Pb (μg/l)	1.05	1	1.1	5.2	0.4	1.1	1.5	0.12	0.08
Cu (μg/l)	15	0.32	0.4	4.5	1.5	1.4	2.1	0.1	0.09
Zn (μg/l)	0.06		3.5	7.2	12	4.5	0.7	0.4	1.2
Phenols (μg/l)	10		3	8	24	5			
PH (μg/l)	90	20	30	30	20	40	30	10	

Table 1. Contamination of Arctic Seas

The concentration of PH in different areas of the White Sea is very variable. It rarely exceeds the maximum permissible concentrations (MPC) -50 μg/l. It is important to note that high PH concentrations were found in some areas of the sea, but even in bays these concentrations rarely exceeded MPC. While emphasizing the fact of low petroleum contamination of the White Sea in general, it is impossible to ignore the significant role of hydrodynamic factors (especially tidal currents), which result in mixing and dilution of contaminants in the water mass and determe their movement from one sea area to another.

During the period 1991 to 1997, the average levels of PH in the Barents Sea did not exceed MPC (50 μg/l); they varied from zero to 40 μg/l. It has not been possible to find

any patterns or trends in their distribution. The maximal PH concentrations (because of accidental spills or deliberate dumping) were, however, significant. Thus, in Kola gulf in 1992 a concentration of 1.55 μg/l was found, compared with 1.13 μg/l in the open sea. In 1993 the maximal PH concentration in Kola gulf was 0.40 μg/l, and in 1994–1.40 μg/l, while the level of contamination of the Barents Sea (with the exception of Kola gulf) by petroleum hydrocarbons was generally insignificant. Thus, in 1995 in the Sea of Pechora the concentration of oil products did not exceed 25 μg/l.
Petroleum hydrocarbons were not found in bottom sediments of the open Barents Sea during studies conducted in 1994 to 1997, but in Kola gulf the petroleum contamination of sediments reached high levels. In 1991 concentration of petroleum hydrocarbons in sediments varied from 0.79 to 1.78 mg/g dry weight, and in 1992 - 0.40 to 0.71 mg/g dry weight; in 1993 the figures were 0.08 to 1.28 mg/g, and in 1994, 0.03 to 0.39 mg/g dry weight. In other coastal areas and bays petroleum hydrocarbons were observed in trace amounts or were absent.

In 1991/1992, the concentration of petroleum hydrocarbons in the open Kara Sea varied from zero to 20 μg/l. In Baidaratsk, Ob, and Taz inlets it did not exceed 50 to 70 μg/l. Exceeding of MPC was observed near Cape Harasaway (up to 92 μg/l) and near the Arctic settlements of Amderma and Dikson, (more 200 μg/l). Somewhat lower PH concentrations were observed in 1993/94; the PH content in the Ob inlet in 1994 was 100 μg/l. In 1995 in the water mass of the Kara Sea, the average PH concentration was 23.7 μg/l. The maximum was found in Yenisei Bay, at 105 μg/l.

During 1991–1997 in the Sea of Laptev, the PH concentration in open areas varied from 15 to 20 μg/l. Concentrations above MPC were observed in the Tiksi inlet (70 μg/l), the Buor-Haya inlet (130 μg/l), and Olenyok Bay (80 μg/l). In 1997 in coastal areas, average PH concentration turned out to be 24 μg/l.

The PH concentration in the East Siberian Sea in 1991 was 16 μg/l, and the maximum in the Chaun inlet was 50 μg/l. In 1993 PH concentrations slightly increased to 27.2 μg/l, with maxima of 80 μg/l at New Siberian Islands and Wrangel Island l.

In 1991 in the Chukchi Sea, PH concentration was low, with an average of 7 μg/l. In the period 1992 to 1995 it slightly increased, to 10 μg/l. The highest concentration of PH was revealed in the area of Vankarem. Since then, general low levels of PH concentration have been found.

Every component of the ecosystems of the Chukchi Sea was found to contain benzo(a)pyrene (BP), a carcinogenic PAH, which can be a component of oil. Some PAHs, including. BP, are easily transformed into mutagenic and carcinogenic substances. In 1997, BP concentrations in the Chukchi Sea reached 0.01–0.5 ng/l in surface water, and 0.01–0.6 ng/l in the near bottom water. The average BP concentration in bottoms sediments was about 2.28 μg/kg. But accumulation coefficients of benzo(a)pyrene in suspended matter and biota appeared to be very significant: 10^2–10^3.

Chlorinated hydrocarbons: Current investigations are indicative of the global distribution of chlorinated hydrocarbons in the World Ocean. Chlorinated hydrocarbons are grouped in several basic classes:

- chlorinated biphenyls presenting a mixture of biphenyls replaced partially or fully by chlorine atoms;
- aliphatic chlorinated hydrocarbons including cyclic (e.g. hexachlorocyclohexane (HCH) and non-cyclic (e.g. dichloroethane) hydrocarbons;
- aromatic chlorinated hydrocarbons (DDT),
- hexachlorobenzenes (HCB), and
- chlorinated products of diene synthesis (aldrin and dieldrin).

Most compounds have been used as pesticides by different countries, particularly hexachlorobenzenes, hexachlorocyclohexanes, especially γ-isomer (lindane), DDT and its metabolites DDD and DDE as well as such cyclodienes as aldrin and dieldrin.

Chlorinated hydrocarbons are recalcitrant high-molecular organic compounds. They have mutagenic and carcinogenic properties and belong to the category of the most hazardous pollutants in the biosphere. The long residence time of chlorinated hydrocarbons (several decades), and their resistance to processes of microbial degradation (especially in low temperature conditions) determines their active circulation along food webs and accumulation in marine organisms, including valuable fish species.

Chlorinated hydrocarbons have a wide distribution in the Arctic seas. The highest concentrations are found in Barents and White Seas (Figure 1c).

In the White Sea the highest levels of chlorinated hydrocarbons are typical of estuaries, bays and seaports. In the period 1991 to 1997, in the open areas of the White Sea, concentrations of HCH isomers occasionally reached 1–2 ng/l. Maximum levels of these contaminants were observed in Kandalaksha and Dvina bays of the White Sea. In the period 1996–1997 a trend of decreasing HCH and DDT concentration was found in Dvina Bay. In 1997 the concentration of α -HCH and γ -HCH was about 0.6-1.2 ng/l, on average.

In the Barents Sea (including bays) during the period 1991 to 1994, DDT was not found in seawater, but, in 1995, low DDT concentrations were found in the Sea of Pechora. In 1997 the concentration of DDT in waters of the Pechora Sea varied from 0.4 to 0.7 ng/l.

In selected areas of the Barents Sea relatively high concentrations of α- and γ-HCH were found in the period 1991 to 1994 (average levels of 4.4 ng/l and 2.3 ng/l respectively). In 1996 α-HCH was not found in Kola bay and the average concentration of γ-HCH was about 1.2 ng/l. In 1997 the concentration of α-HCH and γ-HCH was 0.1 ng/l, and 2–3 ng/l respectively. In 1995 in the Sea of Pechora α-HCH concentration varied within the limits 0.6 to 2.2 ng/l, and γ-HCH, 0.6 to 2.0ng/l. In 1997 their concentrations in Pechora Sea were about 0.98 ng/l and 1.2 ng/l correspondingly. The same level of contamination by HCH-isomers was found in the samples in sea ice. It is worth noting that the maximum concentrations α-HCH and γ-HCH (9.62 and 9.68 ng/l respectively) were found in the snow cover on the sea ice. The data presented confirm -

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Bibliography

GESAMP (1986). *Environmental Capacity, An Approach to Marine Pollution Prevention, Report and Studies*, No. **30**. [The concept of environmental capacity of marine ecosystem to pollutants is presented in this Report.]

Goldberg E.D. (1995). *Emerging Problems in the Coastal Zone for the Twenty-First Century. Marine Pollution Bulletin*, .**31** (4–12), 152–158. [Contemporary state and the most important problems in the coastal zone for the twenty-first century are described in this paper.]

Izrael Yu. A. (1999). *Arctic and Ecological Sustainable Development*, in: *Anthropogenic Impact on Northern Nature and its Ecological Consequences.* Monographic collection under editorship of academician Ras Yu. A. Izrael, Prof. J. V. Kalabin, Prof. V. V. Nikonov, Apatity. Print K. S. C. Ras. pp. 7–17. [The problems of the Arctic state are discussed in the light of the concept of ecological sustainable development.]

Izrael Yu. A., and Tsyban A. V. (1989). *Anthropogenic Ecology of the Ocean, Gidrometeoizdat*, 528 pps. (In Russian) Leningrad. [Scientific justification of this new branch of the contemporary oceanology is given in this book; special attention is paid to the problem of biogeochemical cycles of contaminants in marine environments and ecological consequences of chemical pollution upon marine organisms and ecosystems.]

Izrael Yu. A and Tsyban A. V., eds. (2000). *Dynamics of the Bering and Chukchi Seas Ecosystems, Nauka*, 358 pp. Moscow Publishing House. [The book is devoted to the dynamics of the oceanographic, hydrochemical, hydrobiological, and biogeochemical cycles of contaminants in the Bering and Chukchi Seas.]

Moiseyev P. A. (1995). *The State, Trends of Development and the Future of Fishery and Aquaculture, Biological, Commercial, and Economic Problems of World Fishery. Review Information*, 2, 1–48. (In Russian). [The state of the world fishery.]

Moss. R. H., Watson R. T., and Zinyowera M. C., eds. (1996). *Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. [This book is devoted to the science of climate change including marine biotic responses to environmental change and feedbacks to climate.]

Tsyban A. V. (1997). *Ecological Problems Associated With Human Activities Affecting The World Ocean, Journal of the Oceanographic Society of Japan* **6**(11), 61–68. [This paper presents the problems of chemical pollution of the ocean and its consequences. Special attention is paid to exploitation of living marine resources.]

Tsyban A. V. (1999). *Ecological Investigations in the Russian Arctic Seas: Results and Perspectives, Aquatic Conserv: Mar. Freshw. Ecosystem* **9**, 503–508. [Contamination of the Arctic seas and the role of biological processes in the transport and elimination of pollutants are described.]

Zalogin B. S. and Kosarev A. N. (1999). *Seas*, 400 pp. (In Russian). Moscow Publishing House. [Physical and geographical peculiarities of World Ocean seas are presented in this book.]

Biographical Sketch

Alla Victorovna Tsyban is a noted scientist in the field of bio-oceanology. She is one of the founders of the new line of modern oceanology: the anthropogenic ecology of the ocean. She first combined ecological and biogeochemical approaches to the study of ecological consequences of ocean pollution and carried out these investigations at the population and ecosystem levels. She has also obtained valuable scientific results of fundamental biological investigations in the field of sea-air interaction as well as in the field of marine microbiology, bio-indication of chemical pollution in the marine environment, scientific grounding of ecological monitoring, etc. A. V. Tsyban has published more than 200 scientific papers as author or co-author, including six monographs dedicated to investigations of ecological consequences of World Ocean pollution.

A. V. Tsyban has participated in 23 marine scientific expeditions and headed 12 international expeditions in the Baltic, Bering, Chukchi Seas and Central Atlantic Ocean. In 1976 a biological monitoring network for the seas of the USSR (Russia) was organized under the guidance of A. V. Tsyban. The author is the corresponding member of the Russian Academy of Sciences on the specialty of “Oceanology” at the RAS Department of Oceanology, Physics of the Atmosphere and Geography. A.V. Tsyban is a member of the National Oceanographic Committee of Russia, a member of the US National Geographic Society, a member of the Editing Boards of a number of national and international journals, and an initiator and organizer of several international symposia. A.V. Tsyban is an Honored Scientist, Deputy Director of the Institute of Global Climate and Ecology.