WHITE PAPER

LEAD CONTAMINATION OF THE ENVIRONMENT IN THE RUSSIAN FEDERATION AND ITS EFFECT ON HUMAN HEALTH

STATE COMMITTEE FOR ENVIRONMENTAL PROTECTION OF THE RUSSIAN FEDERATION

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The preparation of this White Paper was conducted on the basis of official materials from the ministries, departments, and institutions of the Russian Federation that are concerned with the problems of lead contamination of the environment and the prevention and elimination of harmful effects of lead on the environment and human health. Detailed attention is given to the sources of those discharges and disposals into the biosphere of materials that contain lead, the production of wastes, the presence of lead in various natural media on the territory of Russia, the health conditions of the population in areas with heightened levels of lead, and the measures being taken to address the problem of lead contamination of the environment in Russia.

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INTRODUCTION

The contamination of the environment by lead and its compounds, leading to the degradation of residential areas and damaging human health, is one of the most acute environmental problems in Russia, having at the same time an important social and economic significance as well.

The prevention and reduction of the level of lead contamination is considered by all developed countries to be one of the most important tasks of environmental policy. These issues were at the center of attention at the International Conference for the Prevention of Lead Poisoning in Children (USA, Washington, DC, May 1994), the First International Conference on the Problem of Lead (Australia, New Castle, June 1994), the International Meeting "The Effect of Lead and Other Heavy Metals on the Health of Children" (Moscow, September 1995), the International Symposium "Heavy Metals in the Environment" (Russia, Pushchino, October 1996), and other forums.

Issues of preserving the environment and human health from the harmful effects of lead and lead compounds were addressed during the proceedings of the International Lead Research Group, which is one of the branch trade organizations that grew out of the UN Commission on Trade and Development (UNCTAD).

The Committee of the European Economic Commission of the UN on Environmental Policy established a Working Group for the preparation of a European strategy to ban the production of leaded gas, the first meeting of which took place in Geneva in November 1996.

The threat that lead contamination poses to environmental safety was the subject of consideration at a meeting of the InterDepartmental Commission for Environmental Safety of the Security Council of the Russian Federation on 20 February 1996.

In addition, the Russian Federation lacks a coordinated government policy for reducing the dispersion of lead into the environment, rehabilitating contaminated areas, and applying sanitary measures.

The situation that is emerging in Russia has created a need to develop a long-term strategy and concrete plans that can be applied in the mid- and short-term to solve the problem of lead contamination.

During the course of the sixth session of the Russian-American Commission for Economic and Technological Cooperation (29-30 January 1996), at which plans for joint activities in the area of environmental protection were discussed, the Minister of the Environmental Protection and Natural Resources of the Russian Federation, V. I. Danilov-Danilian, expressed the opinion, during a meeting with the Deputy Director of USAID, T. Dine, that it was necessary to move from the stage of running scientific seminars and performing informational activities on the topic of lead contamination to proceeding with concrete steps. At this meeting, the two sides agreed in principle that the Russian Ministry for Environmental Protection would take the initiative in organizing, jointly with all interested ministries and departments, the preparation of a Report on this problem and carry out this work within the framework of the joint project with USAID. During the course of spring 1996, this idea received theoretical support and both sides took steps to see that it was implemented.

The main goal of the *White Paper* "*Lead Contamination of the Environment in the Russian Federation and Its Effect on Human Health*" is to present to the Government of the Russian Federation objective and systematic data on the problem of lead contamination of the environment and its effect on the health of the population so that the Government can formulate priority policy objectives in order to lower risks associated with the negative effects of lead.

The objectives of this *White Paper* are to evaluate and summarize materials concerning:

- the basic sources of technogenic introduction of lead into the environment in Russia;
- the degree of actual environmental contamination by lead and lead compounds in Russia;
- the effect of lead on human health;
- the degree of risk that lead contamination poses for the population and especially children;
- the legal, regulatory, economic, scientific, and informational aspects of the issue;
- measures that can be taken to prevent and lower lead contamination of the environment and its negative effects on the population.

The organization, coordination of the preparation of this document, and quality control during the process of researching and writing was carried out by the InterDepartmental Working Group (IWG) formed by order of the Ministry of Environmental Protection of Russia, dated June 21, 1996, No. 290, and includes as members: V. I. Danilov-Danilian, Chairman of the IWG; Iu. N. Iudintsev, Deputy Chairman of the IWG; D. A. Dzhangirov, Deputy Chairman of the IWG; N. G. Bobrov, Executive Secretary of the IWG; P. K. Bogdanov, V. P. Kuznetsov, A. E. Danilina (State Committee for Environmental Protection, RF); G. P. Alekseichuk, I. V. Kalenskii, L. V. Sadikov (Ministry of Industry, RF); S. I. Ivanov (Ministry of Health, RF); L. V. Leonenko (Ministry of Natural Resources, RF), A. L. Plechev (Ministry of Transport, RF); Iu. S. Tsaturov (Russian Federal Service for Hydrometeorology and Environmental Monitoring); V. V. Shelikhov (Ministry of Fuel and Energy); E. N. Efremov

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This *White Paper* is the first of its kind. It is based on data provided by the State Statistical Committee, branch ministries and departments of the Russian Federation, federal services for the monitoring and control of the environment, territorial health and environmental protection organs, scientific and planning organizations, and printed sources.

This *White Paper* is published in two versions: the main report, designed to be presented to the Government of the Russian Federation and containing an in-depth analysis of the problem of lead contamination of the environment in Russia and its effect on human health, and a short version (the present *White Paper*) in both Russian and English, intended to inform organs of state power at all levels, organs of environmental protection, enterprises, organizations, and institutions, and to be disseminated widely among the corresponding organs of foreign governments, international organizations (including those with environmental and financial objectives), and the Russian and foreign public.

This *White Paper* was approved at an expanded session of the Board of the State Committee for Environmental Protection of Russia with the participation of members of the IWG on December 26, 1996, Protocol 1.

EXECUTIVE SUMMARY

The contamination of the environment by lead and lead compounds is recognized around the world as one of the main problems affecting the environment and the protection of human health. The governments, businessmen and the general public of a number of countries take essential efforts to protect the environment and the citizens from the negative impact of lead. The Russian Federation lacks a coordinated government policy regarding the legal, regulatory, and economic regulation of the lead's effect on the state of the environment and on human health, the reduction of discharges (disposals, wastes) of lead and lead compounds into the environment, and the complete cessation of the production of leaded gasolines.

The main *goal of this White Paper* is to provide the Government and people of the Russian Federation with objective information on the issue of lead contamination in the environment, human exposure to lead, and its effect on human health. On the basis of this information, the *White Paper* recommends first steps that the Government can take to prevent and decrease the level of lead contamination in the environment and its effect on human health.

The materials of this *White Paper* demonstrate that, despite a significant decrease in discharges of lead and lead compounds by stationary sources, the problem of lead contamination in the environment in Russia is, at the present time, very real. It is noted that the conditional decrease in the discharge and disposal of lead into the environment as a result of a fall in industrial production during the last five years presupposes a potentially significant increase in these indicators as the country's economy regains its strength.

Lead and lead compounds are part of a class of highly dangerous substances capable of causing appreciable harm to human health. The amount of scientific data is growing that addresses the harm that chronic exposure of lead poses to the organism. The most disturbing evidence about lead pertains to its negative health effects on children. Lead affects the nervous system, which leads to lower IQ levels as well as causes changes in physical activity, coordination, and hearing. Lead also causes changes in the cardiovascular system, leading to heart disease. Some of these negative health effects can be reduced through proper medical treatment, but some effects are permanent. There is also evidence that exposure to lead damages the female and male reproductive systems, which results in higher levels of miscarriages and birth defects. High concentrations of lead in the environment cause an increase in its presence in the human organism and can destroy human health, which is especially clearly visible within the zones of influence that surround stationary sources of contamination.

A calculation of risk shows that, at present-day levels of contamination in the environment and foodstuffs, 44% of children in Russian cities may develop behavioral problems and learning difficulties as a result of exposure to lead; approximately 9% require medical treatment; the health of 0.2% of children is in danger; and about 0.01% of all children require immediate medical intervention. Especially disturbing is the situation in cities with large stationary sources of lead discharge. For example, in Krasnouralsk (where the average content of lead in the blood of children is 13.1 +/- 0.5 mcg/dl with a maximum permissible amount of 10 mcg/dl), a lag in mental development has been observed among 76% of the city's children.

Lead poisoning holds first place among professional intoxications.

The main route for lead to enter the human organism in the Russian Federation is through foodstuffs that are contaminated by lead.

The main source of lead contamination of the atmosphere in the Russian Federation is *automotive transport* that uses leaded gasoline--approximately 4,000 tons of lead in 1995. Discharges by autotransport are several times greater than direct industrial emissions. Correspondingly, some territories of the Russian Federation (Moscow, Tatarstan, etc.) have developed programs to reduce or even completely stop the use of leaded gasolines.

If immediate measures to cut down the production and use of leaded brands of gasoline are not put into effect across the country, then a notable increase in the rate of car ownership could cause a rise in lead discharges in the Russian Federation.

The Government has approved a target program on "Fuel and Energy," which contains a subprogram on "Reconstruction and Modernization of the Oil Refining Industry." The goal of this program is to have unleaded gasoline production account for 65% total gasoline production by the year 2000 (up from 46.9% in 1995 and 26.8% in 1992). However, the fulfillment of this program is notably lagging.

This *White Paper* recommends that the Government develop a mobile source emissions control policy, emphasizing economic mechanisms. It is recognized mobile sources are major contributors of lead as well as other pollutants such as nitrogen oxides, hydrocarbons, carbon monoxide, and indirectly ozone. It is necessary, therefore, to work out a general policy of reducing automotive discharges, with the idea in mind that the use of contemporary technological controls (catalytic converters) and alternative types of fuel can solve both these problems. It is necessary to consider in this case the draft laws being discussed within the Committee for Internal Transport of the European Economic Commission of the United Nations, which governs fuel efficiency standards.

In the near future it will be necessary to launch the modernization and construction of new technological plants for the production of high-octane components of gasoline, as well as the development of a system of measures to provide economic stimulation as a means of promoting the use of unleaded brands of gasoline (increasing taxes on leaded brands of gasoline, tax privileges for the producers of quality, environmentally friendly, motor fuels, differentiated customs duties, and taxes on imported foreign automobiles depending on whether they have catalytic converters installed, etc.).

Apart from automotive transport, *aviation* and *space technology* as well as *hunting* essentially contribute to lead contamination of the environment (400 t/yr and 1 400 t/yr respectively).

The main contributors of lead contamination of the environment by *stationary sources* are non-ferrous metallurgical (NFM) enterprises (660 tons/year, or approximately 87% of registered lead discharges of all branches of industry). Of 39 major non-ferrous metallurgical enterprises, just 5 are responsible for over 90% of all NFM emissions. In fact, just two enterprises in the Urals (the Middle-Ural Copper-Smelting Factory--291 t/yr and the Sviatogor-Krasnouralsk Copper-Smelting Plant--170 t/yr) account for about 70% of total air emissions from metallurgical production.

The burning of fuels (coal, oil, and gas) for general energy needs releases about 400 additional tons of lead per year. Unlike emissions from the metallurgical industry, these discharges are geographically distributed widely among all subjects of the Russian Federation. As a result, health risks from these branch industries are notably lower.

Other stationary sources of lead emissions include *glass and ceramics producing enterprises* (100-200 t/yr), as well as *varnish and paint industry* and *defense industry*.

Stationary sources are responsible for discharges of over 50 t/yr of lead into surface waters. Seven car battery manufacturers discharge an additional 35 tons of lead annually through sewer systems.

A priority short list of enterprises emit lead into the atmosphere must be developed. For each priority enterprise an assessment of existing health risks to workers and the nearby populations should be completed to identify the level of health risks that are created from existing and likely future emissions levels in order to define measures for reducing that risk in the near future. Some measures for the prevention and reduction of lead pollution in the environment at metallurgical enterprises are reviewed in *the federal program "The Technical Re-equipment and Development of Metallurgy in Russia (1993-2000)."*

The management of *solid household wastes* (neutralization or reprocessing) remains an important problem for the environmental protection policy of the country. According to experts, at dumps, transport depots, and other places across the territory of Russia at present up to 1 million tons of lead is contained in worn-out car batteries. At present recycling rates, this quantity is growing by 50,000-60,000 tons per year.

A mechanism for managing lead containing wastes will have to be organized within the framework of the federal target program "Wastes." It is necessary to work out a system of measures for the utilization of secondary leaded raw materials, which provides for, in particular, regulating the collection and reprocessing of worn-out car batteries.

Special attention must also be given to removing from use tin cans that contain lead soldering for the production of preserved foodstuffs.

At the present time a large part of the territory of Russia is experiencing lead fall-out loads that exceed the level critical for the normal functioning of the ecosystem. In tens of cities an excess of lead concentrations in the air and soil has been observed that is larger than the values of corresponding maximum permissible concentrations (MPC). A higher level of lead air pollution, exceeding Russian norms (MPC-0.3 mcg/m^3), was observed in 1994-95 in Komsomolsk-on-Amur, Tobolsk, Tiumen, Karabash, Vladimir, and Vladivostok (up to 0.5 mcg/m^3).

Water supply facilities in a series of cities are located in proximity to territories with high lead content. The use of these polluted territories for the cultivation of agricultural products makes it possible for lead to contaminate foodstuffs as well.

In this *White Paper*, available, but often uncoordinated materials on the contamination of various parts of the environment in the territory of Russia have been systematized, making it possible to compare load level and

health risks for all regions of the country, to determine the comparative pollution levels of all subjects of the Russian Federation, and, on the basis of general patterns, identify the specific characteristics of concrete territories. Maximum loads of lead fall-out, leading to the degradation of the surface ecosystems, are being observed in Moscow, Vladimir, Gorkii, Riazan, Tula, Rostov, and Leningrad oblasts.

It is necessary to note that the information system that exists in the country concerning discharges (disposals, wastes) of lead-containing substances by enterprises requires significant improvement. A program of inter-laboratory quality control of measurements of environmental conditions is lacking. The population participates in decision making regarding environmental policy to an insufficient degree. However, it is exactly this problem--of preventing lead contamination on the territory of the country--where the population could play a significant role and become the most important factor in the development and implementation of a governmental and regional policy.

The Government needs to develop a program of environmental education and instruction in order to assist people in identifying those situations where lead contamination is a problem. It is important to organize a system for informing the general population about the threat of lead contamination in the environment, which would provide for the preparation of informational publications about the danger of lead to health, measures of personal precaution, and required procedures for notifying the population of the presence of lead in consumer goods. This educational strategy could perhaps be developed in conjunction with the growing environmental movement in the country.

The prevention of lead's negative impact on the population should become one of the fundamental principles of environmental policy in the Russian Federation. The implementation of this policy, however, is complicated by the fact that lead contamination does not follow clean jurisdictional boundaries of various regulatory authorities. Lead moves from industrial sources across the territory of entire cities. Practically all states are subject to cross-border contamination. The risk of negative effect on human health extends from the on-site worker, who is in indirect contact with lead during the production process, to the entire population through environmental pollution as well as consumer sources containing lead (paints, ceramics, crystal, etc.).

Lead contamination of the environment is preventable. To achieve this goal it is necessary to reduce (and, if possible, completely eliminate) the use of lead in the production of consumer goods, to introduce environmentally safe technologies that conserve resources and result in minimal wastes, to develop and implement a corresponding plan of environmental protection measures in various branches of industry, and to carry out efforts to lower the level of lead in different parts of the environment.

It is important to note that *the prevention of lead contamination in the country* is possible given:

- ⇒ a general conception of environmental safety for the population on a national level under conditions of sustainable development;
- ⇒ a system that provides for complete monitoring of environmental conditions and the screening of the health of the Russian population;
- ⇒ an active system of environmental protection legislation;
- ⇒ effective economic measures to stimulate the introduction of environmentally friendly technologies.

The many-sided nature of the lead contamination problem (multi-media contamination--air, water, soil, foods, etc.; multi-pathway influence--ingestion, inhalation, skin contact; the multi-jurisdictional approach--participation in the solution to the problem by several ministries and departments) is the main reason why managing this pollutant demands the creation of a federal target program to protect the environment and the health of the population from lead contamination.

This *White Paper* proposes a concrete plan of top-priority measures to reduce lead contamination in the environment in Russia and its effect on human health, including immediate measures to solve the problem under consideration and measures requiring task elaboration. The plan is to be implemented at the federal, regional and local levels as well as the industrial enterprise level.

On the **federal level**:

1. Take the necessary measures to carry out:
   - the subprogram "Reconstruction and modernization of petroleum processing enterprises" of the federal targeted program "Fuel and Energy" in the parts that provide for an increase of the percent share of unleaded gasolines in the total production of gasolines;

- the federal targeted program "Technical re-equipping and development of metallurgy in Russia (1993-2000)," where measures are implemented to prevent and reduce lead contamination of the environment;
- the federal targeted program "Wastes".

2. Develop in 1997 a federal targeted program "Protection of the Environment of the Country and Public Health from Lead Contamination for 1998-2005".

3. Implement fundamental and applied scientific research on the problems of lead within the framework of the federal targeted programs approved by the Government of the Russian Federation and broaden the volume and subject matter of research being carried out within the areas of their competence.

4. Attract domestic and foreign investment for the modernization and construction of new technological plants for the production of high-octane gasoline components and the reconstruction of the corresponding metallurgical, chemical, and machine-building enterprises.

5. Accelerate the passage of draft laws of the Russian Federation "On the protection of air quality," "On the protection of the population from the negative effects of oil products," "On production and consumption wastes," "On the vegetable kingdom," and "On the protection of soils".

6. Prepare draft Federal Laws of the Russian Federation "On hazardous substances," "On food products," "On the rehabilitation of land contaminated by heavy metals," "On the evaluation of influences on the environment," "On motor fuels--liquefied and compressed natural gas," "On the sanitary cleaning of territories," and "On packaging and labeling".

7. Prepare proposals on measures for legislative and administrative responsibility for the sale of leaded gasolines in the regions where its use is prohibited.

8. Provide for the organization of a system of complex environmental monitoring for the presence of lead in various parts of the environment, and especially in cities where there are principle sources of lead discharges.

9. Work out a system of measures for the utilization of secondary lead raw products, which provides for, in particular, the orderly collection and processing of worn-out car batteries.

10. Work out measures for the transition to more contemporary production technology for the preservation of food products, which makes provisions for, in particular, removal from use of tin cans with leaded soldering.

11. Secure the development and implementation of necessary measures for the replacement of lead shot with steel in hunting cartridges.

12. Introduce a two-tiered system of medico-biological monitoring, including determination of lead presence in hair for the assessment of environmental danger in different areas and in blood for high-risk groups.

13. Organize the conducting of medicinal-prophylactic measures to lower the risk the influence of lead contamination on the condition of children's health, especially in cities with major sources of lead discharges into the environment.

14. Develop a federal list of territories contaminated with lead that are the most dangerous to human health, as well as a register of stationary sources of environmental lead contamination.

15. Develop proposals for the organization, on the basis of existing laboratories of methodological analytical centers, of a determination of lead in environmental bodies and biosubstrata.

16. Prepare proposals for the organization of a system of public information on the threat of environmental lead contamination, which provide for the preparation of informational publications on the danger of lead's effect on health, measures for individual prophylactic steps, as well as measures for the compulsory informing of the public about the presence of lead in products.

On the **level of the member states of the Russian Federation** and at the local level, the expedient passage of legal and regulatory acts and programs for the regulation of discharges and disposal of lead into the environment, which provides for, in particular:

1. The administrative regulation of the production of leaded gasolines.
2. The creation of a network of specialized enterprises for the collection and processing of industrial and household leaded wastes.
3. The rehabilitation of territories contaminated with lead.
4. The conduct of a set of measures aimed at the prevention of the unfavorable influence of lead on the health of the population (for regions with high levels of lead contamination).
5. The development and implementation of economic stimulation measures.
6. Measures for the rational organization of traffic.

7. Strengthening of the monitoring of the technical condition of autotransport being used.
8. The improvement of the management of transport and the development of public passenger electric transport.
9. The implementation of a municipal development policy aimed at reducing public use of transport.

It is necessary for the administrations of member states of the Russian Federation in regions where essential sources of lead contamination are located, for the territorial nature protection organs, together with scientific institutes and other interested enterprises, to form special scientific-technical programs for the prevention of lead contamination of the environment.

On the **level of industrial enterprises**, which have a part in the contamination of the environment by lead, it is necessary to address the following issues:

1. Changes to the technology of the fusing of lead and its alloys, copper, zinc, and other metals (the universal use of electric kilns, non-flux fusion), the improvement of sanitary-technical devices.

2. The creation of a capacity for processing secondary raw lead.

3. The introduction of advanced technological processes and equipment for the production of high-octane, unleaded gasolines.

4. The refusal to use lead pigments in the production of decorative paints, replacement of them by ferrates, titanates, and aluminates. In this regard, a necessary measure is the organization of strict environmental monitoring (both governmental and industrial).

5. Conducting of technical re-equipment of car battery plants with an application, in particular, of equipment with a streamlined purification of discharges into the atmosphere and the absence of drainage (reverse water supply).

6. The securing of changes in the construction of automotive engines in order to substitute leaded gasoline with alternative forms of fuel (natural and liquefied oil gaseous, alcohol fuel, biogas, hydrogen, etc.) and electric energy.

7. The increase in fuel economy (energy efficiency) produced by domestic means of transport that have a higher (by 20-30%) fuel consumption in comparison with foreign analogs.

1. CHARACTERISTICS OF THE PROBLEM OF LEAD CONTAMINATION OF THE ENVIRONMENT IN RUSSIA

For a long time people have mined and used lead in various spheres of economic activity. It has also been long known that lead has a negative effect on human health: as early as the second century B.C. symptoms of "saturnism" were recorded, i.e., lead poisoning.

During the course of a century the uses made of lead have undergone serious changes: from simple goods (ammunition, metal wares, components of paints, glazes, typographical alloys, etc.) to its application in the most complex of articles. The industrial era has witnessed a steady growth of its use and production: in 1995 its worldwide use was 5.56 million tons and production--5.43 million tons (fourth place among non-ferrous metals, following aluminum, copper, and zinc). In 1997, expected use is 5.86 million tons and production--5.92 million tons.

1.1. Sources of Environmental Contamination

1.1.1. Stationary sources

The contamination of the environment with lead and lead compounds by the **metallurgical industry** is a result of the specific character of that industry's manufacturing activities, such as the direct production of lead and lead compounds, the accompanying extraction of lead from other raw materials that contain lead in the form of an alloy, and the purification of the end product of lead alloys, etc.

In 1995, of the total discharge of lead (671 tons) by the metallurgical industry into the atmosphere, approximately 98.4% (660 tons), came from *non-ferrous metallurgical* enterprises. Out of the 640 kg/year of lead that is discharged into bodies of water containing sewage water, 89% (570 kg) belonged to enterprises producing non-ferrous metals. The relatively small discharges of lead by ferrous metallurgical enterprises in the Russian Federation is a result of the absence in the raw materials being used of any significant amounts of lead, although in a series of developed countries the presence of lead in raw ore and scrap creates serious environmental problems in blast, open-hearth, and electric-smelting processes.

99.86% of lead discharged into the atmosphere originates with 11 out of 39 non-ferrous metallurgical enterprises, with 94% of this metal being discharged by 5 enterprises: Middle-Ural Copper-Smelting Factory (291 t/yr), JSC Sviatogor-Krasnouralsk Copper-Smelting Plant (170 t/yr); Kirovgrad Copper-Smelting Plant (11 t/yr); JSC Dalpolimetall (28 t/yr); and the Electrozinc factory (16 t/yr).

An analysis of the sources of lead discharges has shown that:

- 57% of lead is discharged into the atmosphere along with large volumes of particle-filled gases from the reverberatory smelting of copper (lead-containing) ore, which at each of the factories that use this technology is directed through smokestacks without filtering;
- 37% of lead is discharged along with converter gases due to the absence or insufficient degree of purification of lead that is saturated with sublimated particles;
- the inadequacy of particle detection systems available at non-ferrous metallurgical enterprises in the Urals is a vital factor that also determines the amount of lead discharges into the atmosphere.

The *production of car batteries* in the **machine tool industry** consumes half of the lead that is used in the country. In 1995, total discharges into the atmosphere by seven car battery plants in Russia, which form the JSC Elektrozariad, made up approximately 38.2 tons in terms of lead; total disposal into bodies of water (through sewers) was 35.3 tons.

With the transition to using plastic materials for casing in the *production of cables*, cable factories have decreased their consumption of lead and lead alloys. At the present time, the consumption of lead within factories of this sub-industry has decreased to 5,000 tons. The characteristics of the technology now being applied are such that discharges of lead are insignificant.

In the **fuel and energy sector** environmental lead contamination is caused by the production of leaded gasolines and the burning of fuel (above all coal).

In 1995, 27.4 million tons of gasoline for automobiles was produced, including 14.5 million tons of leaded gasoline. The lead content in leaded gasolines varies from 0.15 to 0.37 g/l. It should be noted that unleaded gasolines, because of the production technology and transportation, may contain lead in a concentration of 0.01 g/l.

At the present time, 9 out of 25 petroleum processing refineries produce only unleaded gasolines, while in 1990 the number of such refineries was only 6. During the first half of 1996, the production share of unleaded gasolines was 51.2% (in 1995 it was 46.9% and in 1992, 26.8%).

Despite this positive downward tendency in the production of leaded gasolines, there are a series of economic and organizational reasons that are delaying a solution to this problem. The refusal to utilize ethyl alcohol and the use of alternative octane-increasing additives pushes the cost of the automotive fuel up.

Calculations using official statistical data on the consumption of fuel by member states of the Russian Federation in 1993 showed that during the *burning of organic fuels* (coal, oil, gas), approximately 400 tons of lead is introduced into the atmosphere in Russia.

Discharges and disposals of lead compounds in the **chemical sector** are tied to the production of pigments, siccatives, specialized glasses, lubricants, antiknock agents for automotive gasolines, the polymerization of plastics, etc.

In Russia, *ethyl alcohol* (*on the basis of tetraethyllead*) is produced only by one enterprise, JSC Synthesis (Dzerzhinsk, Nizhnii Novgorod oblast). The production of ethyl alcohol at this enterprise has decreased by two times relative to levels at the end of the 1980s and in 1995 totaled 8,900 tons. In 1996, proposed production volumes of ethyl alcohol total 11,500 tons. This growth in production is a result of forthcoming export orders (30-40% of production).

The decrease in the production of ethyl alcohol at JSC Synthesis has been made possible by the production of alternative octane-increasing, oxygenated agents--MTBE and feterola (a mixture of MNBE and tributyl alcohol) - at a number of other enterprises (Moscow and Omsk Petroleum Processing Refineries, JSC Nizhnekamsk Petrochemical Plant, Toliatti and Volga synthetic rubber factories).

In the *varnish and paint industry* they continue (more recently in decreasing amounts) to use *lead pigments*. Pigments containing lead are used also in anti-corrosion finishes which have primarily a protective and not a decorative use.

In Russian enterprises in 1994, a total of 800 tons of lead minium were produced, which contained 725 tons of lead proper. In contrast to crystal manufactures, where the probability that lead will leach during household usage and have an effect on the human organism is practically excluded, lead paints present a greater danger. In correspondence with the Law of the Russian Federation "On Hazardous Chemical Substances" and the Law of the Russian Federation "On Consumer Rights," lead paints cannot be used for coatings with which humans have direct contact.

On the whole, discharges into the atmosphere of lead compounds by varnish and paint industry enterprises constitute a magnitude in the order of 20 tons. This figure is an estimate, but the order of magnitude itself justifies that a detailed inventory of the use and wastage of lead compounds in this sub-industry be conducted.

Lead discharges made by **glass enterprises** on the whole in Russia are estimated at a magnitude in the order of 100-200 tons/year. The production of crystal dishware, optical flint glass, parts for television tubes, and special lead glass for soldering with metals and other glasses should all be considered as sources of environmental contamination, primarily, of the air by lead compounds. The wastage of lead at these enterprises constitutes 2-8% of the mass of the element drawn into the technological process. The concentration of lead in waste gases during the heating of low-leaded glass constitutes up to 600 mg/m^3.

In the **canning industry** (the use of leaded soldering in the preparation of tin cans), according to estimates for 1988, 100-200 tons of lead was used. Taking into consideration the decrease in the production of canned goods in the 1990s, the yearly mass of lead making up solid household wastes at the present time may constitute tens of tons. An even greater danger is presented by the possibility that the lead, which is contained in the soldering, may penetrate into the foodstuffs during storage (see section 3.1).

Important sources of environmental contamination by lead and lead compounds are the enterprises of the **defense industry**. Soldering and other assembly work allow 1 ton/year of lead to be emitted into the low-level atmosphere as a whole in Russia. Varnishing and painting, impregnation, and enameling, as well as working with the application of compounds, make possible emissions of lead and its inorganic compounds of up to 150 tons/year, not calculating those chemical substances with a high proportional content of lead, but which have limited application. The emission of lead into the environment also takes place during the production of leaded ammunition, the application of leaded coverings, and other specialized work.

Dumping sites for solid household wastes are major sources of environmental contamination by heavy metals, including lead.

Among those consumer sources of lead that make up solid household wastes, lead car batteries with worn-out wires and cables, varnish and paint coatings (especially that which was produced in earlier decades), goods made of crystal, leaded glasses, glazed ceramics, and soldered wares, including tin cans for food and certain rubber goods, should be included. The content of lead in waste-processing products exceeds that in the crust of the earth by 100-1000 times, i.e., levels reaching 0.16-1.6% by weight.

According to expert analyses, at the present time up to 1 million tons of lead lies in dumps, transport service areas, and other places across Russia in the form of worn-out car batteries. At their present recycling rate, this quantity grows annually by 50-60 thousand tons.

According to data provided by the Russian State Statistical Committee, the rate of discharge of lead and lead compounds from stationary sources into the atmosphere in Russia during recent years has demonstrated a constant downward trend in connection with the decline of production levels. In 1992, 1,404 tons of lead and lead compounds were discharged, 6.9% lower than the 1991 level. In 1993, total discharges of 1,070 tons amounted to a decrease of 13.8% of the 1992 level, while the 1994 figure of 876 tons is 18.1% lower than that of 1993; the 1995 level of 616 tons is 29.8% lower than that of the previous year (Figure 1).

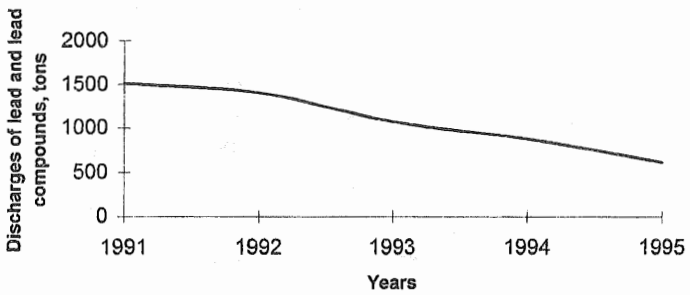


Figure 1. The discharge rate of lead and lead compounds into the atmosphere by fixed sources, 1991-1995

This downward trend in the discharge of lead and lead compounds is also characteristic of the majority of territories of the Russian Federation. Nevertheless, alongside significant decreases in discharges in several regions (lower in Pskov Oblast by 150 times, Irkutsk by 130 times, Arkhangelsk by 15 times, and both Cheliabinsk and Stavropol Oblasts by 10 times) are other areas that have recorded a sustained growth in lead and lead compound discharges in the atmosphere (increases in Murmansk and Amur Oblasts by 10 times and in Perm Oblast and Primorskii Krai by two times, as well as a number of other areas).

It follows, based on 1995 materials, that there are seven regions of the Russian Federation where lead discharges account for more than 1% of the entire discharge of lead in the country; in total, their discharges of lead constitute approximately 95% of all lead discharges from stationary sources in Russia.

Figure 2 presents proportionate discharges of lead into the atmosphere and also lists those cities with the largest stationary sources on the territory of the Russian Federation. Sverdlovsk Oblast holds the top position in causing a negative effect on the environment (68.7% of all discharges). On the territory of this oblast three of the largest sources of discharges are located: in the cities of Krasnouralsk, Kirovgrad, and Revda.

The contribution of different branches of industry to lead contamination of the atmosphere by stationary sources is estimated as follows (data are drawn from the State Statistical Committee of Russia):

- non-ferrous metallurgy: 86.7%
- machine building and metal processing: 8.8%
- ferrous metallurgy: 1.4%
- chemical and petrochemical industries: 0.5%
- wood processing and the paper and pulp industry: 0.3%
- transport enterprises, the food industry, the building materials industry, electrical energy and heating fuels industry: 0.1% each
- other branches of industry: 1.8%.

The presence of lead in bodies of surface water that contain waste waters is also tending to decrease. In 1995, according to data from the State Statistical Committee, lead discharges were 3.1 times less than in 1991, i.e., 50.47 tons in terms of lead. Areas where lead discharges were recorded in 1991, but where such discharges were not detected in 1995, were Karelia, Mordovia, Karachaevo-Cherkesskaia, and Udmurtia Republics and Tver, Nizhnii Novgorod, Saratov, Ulianovsk, and Chita oblasts.

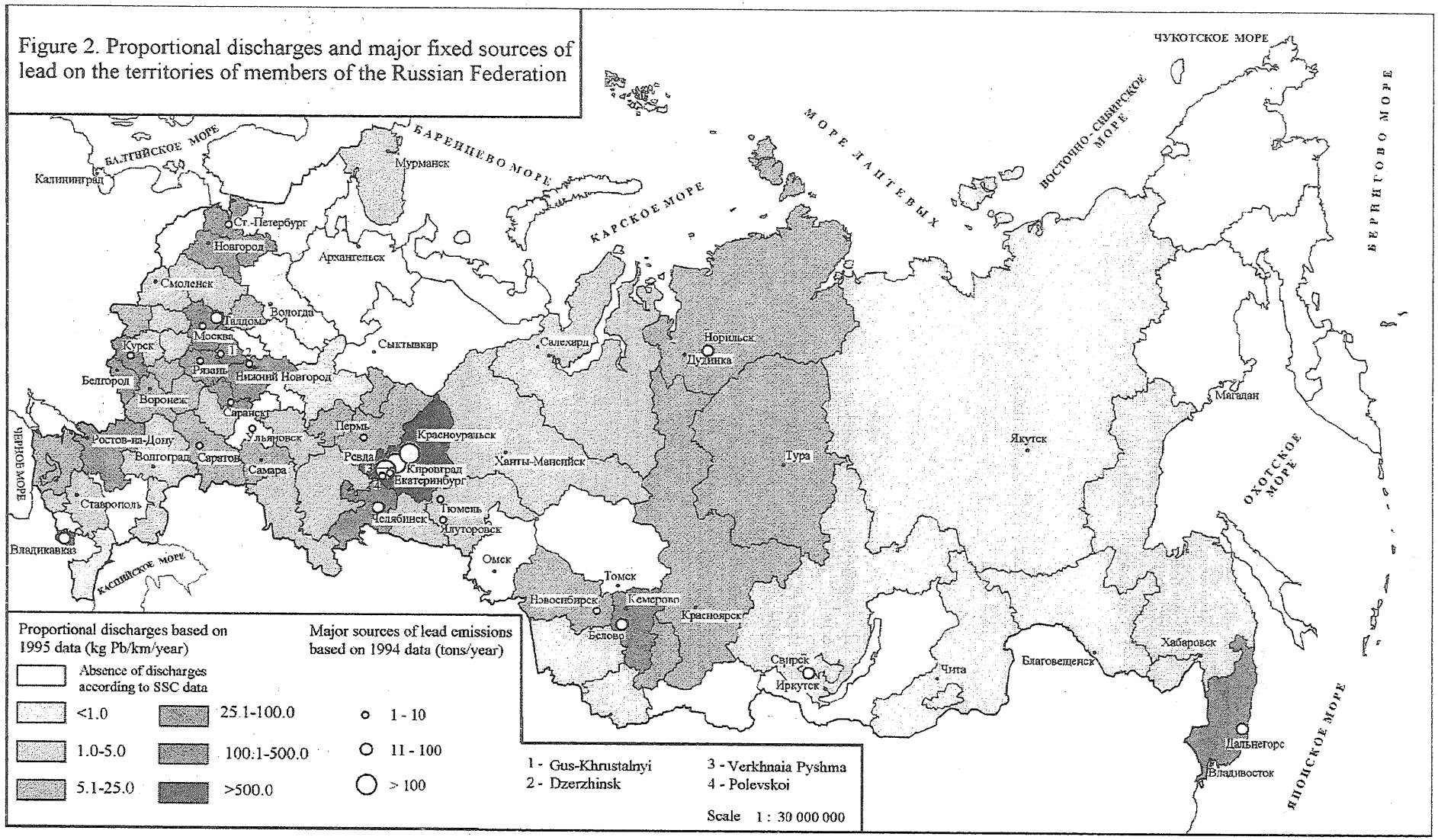


Figure 2. Proportional discharges and major fixed sources of lead on the territories of members of the Russian Federation

The greatest rates of decreasing discharges of lead during the last five years have been observed in Moscow and Moscow Oblast (20 times lower) and St. Petersburg and Leningrad Oblast (7 times lower). An increase in discharges is observed in Arkhangelsk, Orel, and Irkutsk Oblasts, the Republic of Bashkortostan, and in Primorskii Krai.

An analysis of the distribution of lead discharges into surface waters on the territory of Russia, taking into consideration the size of each of the members of the Federation (Figure 3), indicates that Leningrad, Iaroslav, Perm, Samara, Penza, and Orel Oblasts lead in this area.

It should be observed that the indicators used to measure lead discharges into surface waters are fragmentary, because report form No. 2TP-vodkhoz only allows information on the seven largest characteristic contaminants in a discharge to be recorded. Thus, information on lead discharges by large enterprises where lead is not among the top seven pollutants is not included in the available statistics.

At enterprises within the Russian Federation in 1995, 1.9 million tons of lead-containing wastes were created, of which:

used at enterprises:	8,000 tons (0.42%)
completely neutralized:	960 tons (0.05%)
buried:	52,000 tons (2.73%)
stored:	450 tons (0.02%)

The remainder stayed at the enterprise sites or was removed to unsanctioned dumping sites, dumping sites for solid household wastes, etc.

1.1.2. Mobile sources

According to data provided by the Main Computing Center of the State Auto Inspection (GAI), Ministry of the Interior, in 1995 the number of automobiles in Russia was 19.6 million, among which are 14.7 light vehicles, 4.2 million trucks, and approximately 0.7 million buses.

The rate of growth of the automotive fleet in Russia during the last year equals, on average, about 12%. In 1995, the number of light vehicles grew by 15%, trucks by 1.5%, and buses by 5.7%.

During the preceding five years, the composition of the automotive fleet according to the type of fuel being used did not change. The number of vehicles using gaseous fuel does not exceed 2%. Trucks with diesel engines constitute, on average in Russia, 28%, and diesel buses, approximately 63%.

The total amount of lead emitted into the air from autotransport in Russia during 1995 is estimated to equal 4,000 tons. The spatial distribution of lead discharges into the atmosphere (Figure 4) indicates that the maximum lead load from autotransport discharges is located in Moscow and Samara Oblasts. Kaluga, Nizhnii Novgorod, Vladimir, and other members of the Federation located in the central part of European Russia, and the northern Caucasus, come next.

The greatest absolute discharges of lead are noted in the regions of the Urals (685 tons), Volga (651 tons), and western Siberia (568 tons).

Fifty-four percent of the total mass of lead in the atmosphere comes from trucks.

In **aviation,** the use of leaded gasolines B-91/115, B-100/130, B-95/130, etc. by AN-2 and IaK-18 airplanes and by KA-26 helicopters is accompanied by an annual emission of lead and its oxides into the atmosphere of as much as 3.6-3.7 t/yr (refers to the entire fleet of aviation technology mentioned here).

For **aeronautical technology**, the main source of lead contamination is pyrotechnics. The pyrotechnics of greatest use (cartridges, exploding bolts, time fuses, etc.) equipped with percussion-cap detonators and electric detonators with a structure of azido lead and trinitroresorcinate lead (or styphinate of lead) acting as initiators, discharges, among other dangerous substances, lead in a vapor form during explosion. The overall emission of the lead compounds indicated above equals 250-500 t/yr.

The hunting profession and amateur hunting must also be considered as mobile sources of lead discharges into the environment, in particular lead shot contamination of the environment. Estimates indicate that on the whole in Russia up to 1,400 tons of lead end up in waterways and marsh areas.

Table 1 presents comparative data on sources of environmental pollution in the Russian Federation. An analysis of the materials cited in the table indicates that the main source of lead contamination in all parts of the environment in Russia is automotive transport (approximately 70% of all discharges into the atmosphere).

The data provided by the State Statistics Committee of Russia are substantially lower compared with other estimates of lead discharges from fixed industrial sources.

Figure 3. Proportionate Discharges of Lead into Bodies of Water in the Russian Federation (1995)

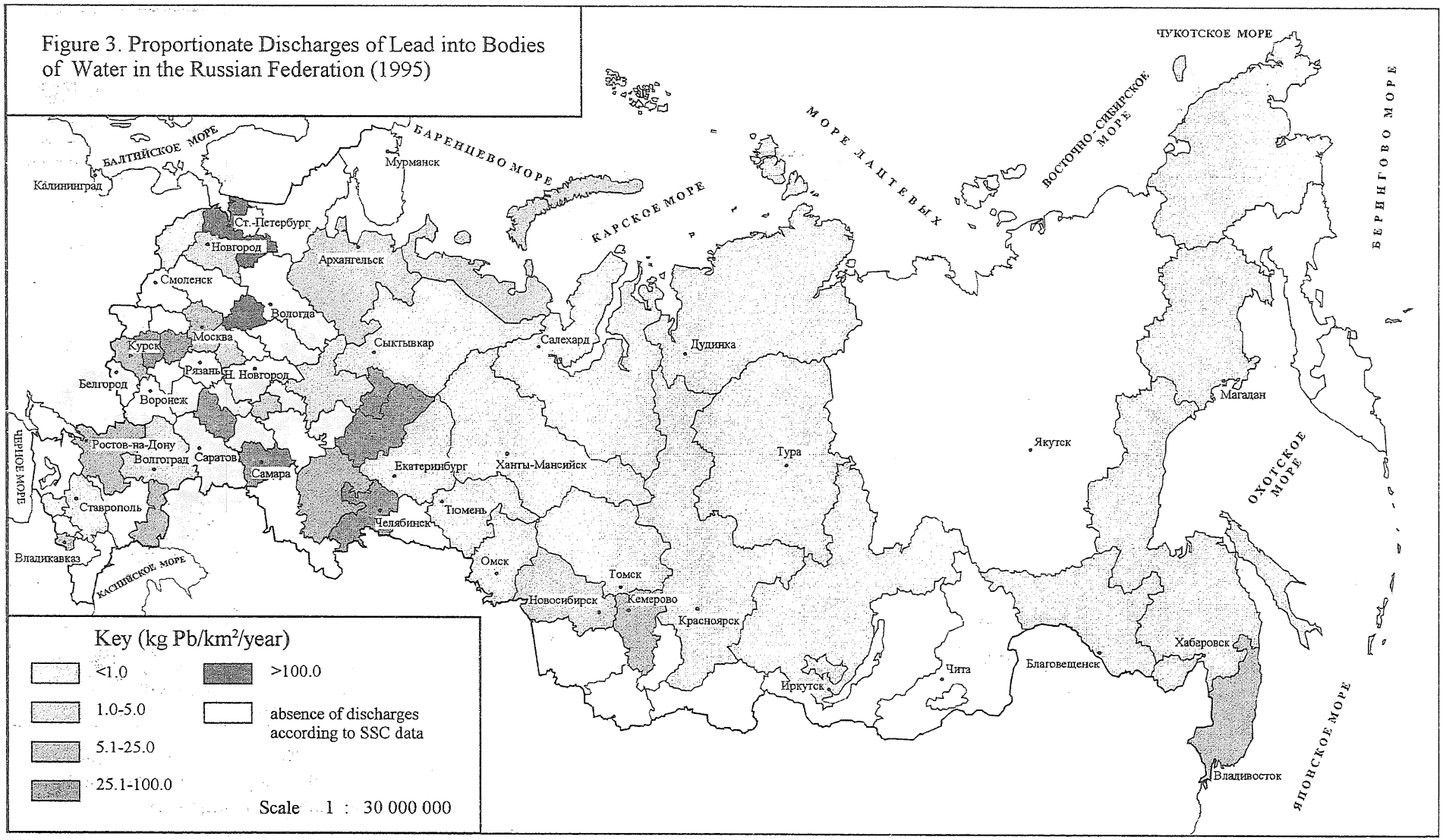


Figure 4. Proportionate Discharges of Lead into the Atmosphere by Vehicles on the Territory of the Member States of the Russian Federation (1995)

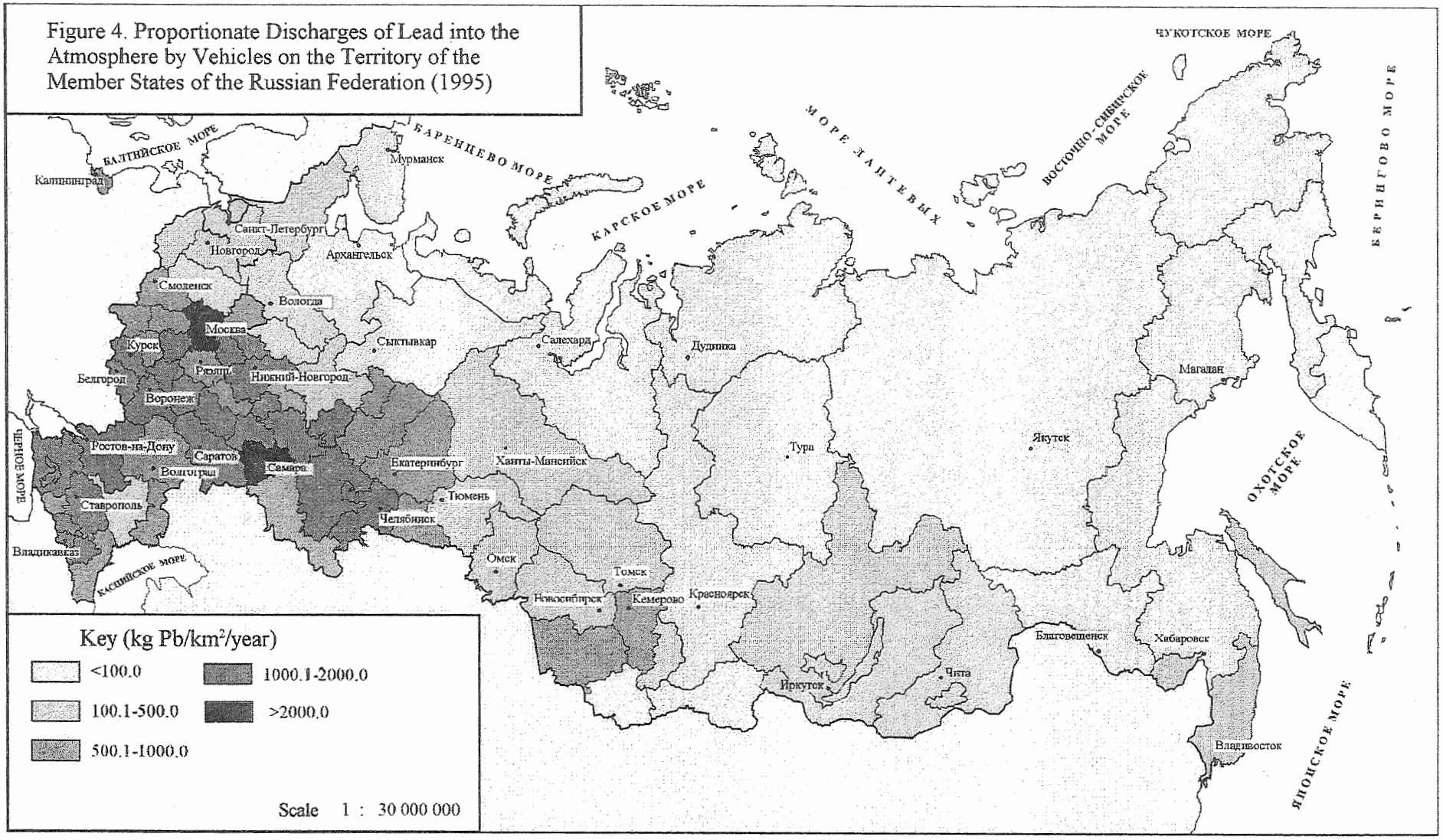


Table 1

Characteristic of Sources of Lead Contamination of the Environment in Russia for 1995 by Industry and Activity (tons of lead)

Source	Atmospheric Discharges	Discharges into Bodies of Water	Waste Production
Stationary sources			
Goskomstat data for all branches	615.5	50.5	1, 864,056*
Industry data:			
Metallurgy	671	0.64	-
of which, Non-Ferrous	660	0.57	900
Machine Building	38.2	35	-
Burning of Fuel (coal, oil, gas)	400**	-	-
Chemical, Petrochemical, and Petroleum Processing Industries	0.94	9.55	725***
Glass Production (estimate)	100-200	15-20	100
Canning Industry (estimate)	-	-	100-200
Defense Industry (estimate)	150	-	-
Non-Stationary sources:			
Autotransport	4,000	1,000****	60,000*****
Aviation and aeronautical and space technology (estimate)	400	-	-
Hunting (estimate)	-	1,400	-

Notes: * Lead-containing wastes of all branches except those used, neutralized, properly buried at official sites or placed in proper storage.
** Estimate for 1993.
*** Production of lead minium.
**** Estimate of the amount of lead that leaked into the ground or water as electrolyte and paste from car batteries during their destruction.
***** Worn-out car batteries except for those collected by the Committee for Secondary Non-Ferrous Metals.

1.2. Analysis of Environmental Contamination

1.2.1. Air

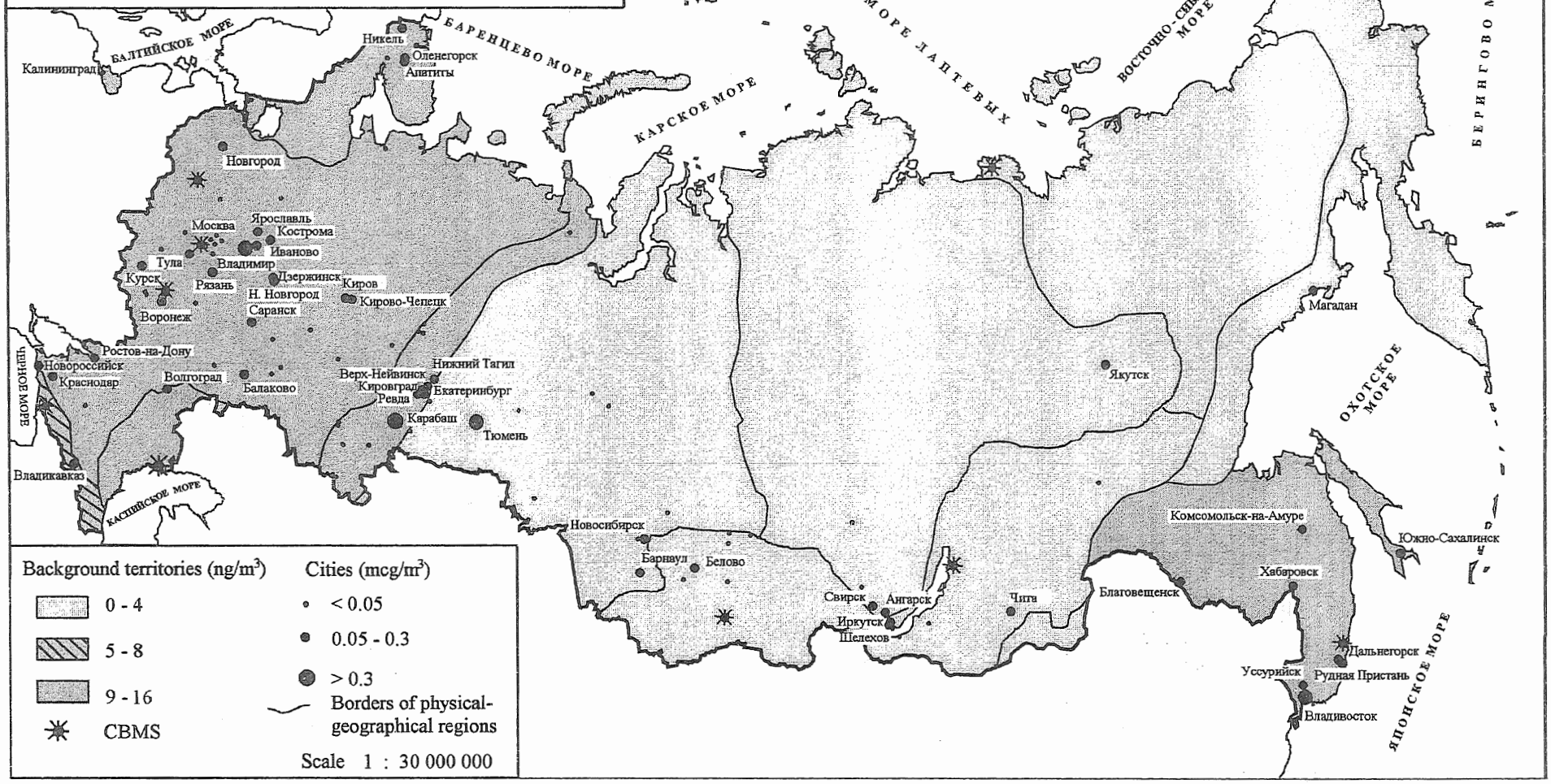
Based on information collected over several years (1982-1995) of observation of the complex background monitoring system (CBMS) of the Russian Federal Service of Hydrometeorology and Environmental Monitoring, the average annual values of lead concentrations **in the atmosphere of the background regions of Russia** equals (Figure 5):

2.5-16 ng/m^3 - for the central part of European Russia
0.8-13.2 ng/m^3 - for the southern regions of European Russia
1.5-4.4 ng/m^3 - for Siberia
5-19 ng/m^3 - for the Far East

In the Russian sector of the Arctic, the background concentration of lead in the air equals 0.23-3.8 ng/m^3 (average monthly values).

The spatial distribution of the background lead content in the air is not uniform and, to a significant degree, is determined by the distribution of its anthropogenic sources on the territory of Russia. The background lead content in the air (the data are from maximally diverse, average daily, monthly, and yearly concentrations) does not exceed the values for maximum permissible concentrations.

Figure 5. The Average Concentration of Lead in the Air of Background Regions, Cities, and Industrial Centers in the Russian Federation (1995)



As a rule, the highest concentrations of lead in the background regions are observed during the winter, which is connected to the additional discharges into the atmosphere of by-products of burnt fuels. Unfavorable meteorological conditions during this time of year promote the accumulation of lead in the lower levels of the atmosphere.

During the past five years a decrease in the presence of lead in the atmosphere has been observed for most parts of Russia (Figure 6), which is connected with the reduction of production and, correspondingly, of discharges within the country, and with the decrease in cross-border transmissions of lead as a result of a reduction in the consumption of leaded gasolines in other countries. The most noticeable decrease in lead concentration in the air is recorded in the central part of European Russia.

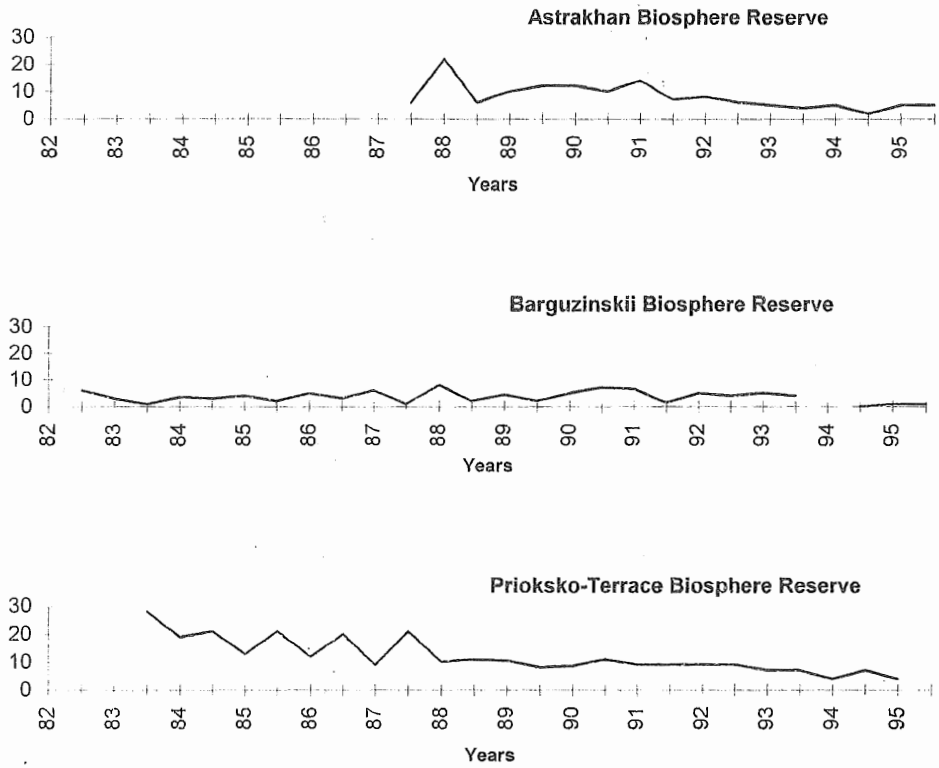


Figure 6. Rates of the background presence of lead (ng/m^3) in the atmosphere at a few of the CBMS stations.

The highest level of environmental contamination is recorded in cities and industrial centers. The value for average concentrations of lead **in the air of urban areas** for 1989-1995 equaled 0.01-0.5 mcg/m^3. For the majority of Russian cities, the average annual concentration of lead did not exceed the value of 0.1 mcg/m^3.

The highest level of atmospheric contamination, which exceeds the values for sanitary norms for air quality acceptable in Russia, was measured during 1994-95 in Komsomolsk-on-Amur, Tobolsk, Tiumen, Karabash, Vladimir, and Vladivostok (up to 0.5 mcg/m^3) (see Figure 5). According to the measurements, the daily mean lead concentrations in the atmosphere of a number of cities often exceed the said values by 10 times and more.

The values for the average monthly concentration of lead in the atmosphere differ in their greater inconstancy compared with data on the average annual content in the air. According to data collected in 1995 in 29 Russian cities, the average monthly concentration of lead exceeded values for maximum permissible concentrations.

Data for 1995 indicate that the average concentration of lead in the air of Russian cities equals 0.07 mcg/m^3.

Industrial sources of lead bring about the contamination of vast territories because of the processes of long-range atmospheric transmission of contaminated air masses.

Based on data from the Meteorological Experimental Center "Vostok," an estimation of the cross-border atmospheric transmission of lead was performed (Table 2).

Table 2.

Balance Sheet of Cross-Border Transmissions of Lead in 1991 for European Russia

Country	Transmission into Russia (tons)	Transmission out of Russia (tons)	Balance (tons)
Albania	1	0	+1
Austria	42	0	+42
Benelux	107	1	+106
Bulgaria	71	12	+59
Czechoslovakia	87	7	+80
Denmark	37	0	+37
Finland	271	103	+168
France	129	4	+125
Germany	320	15	+305
Great Britain	178	6	+172
Greece	12	6	+6
Hungary	35	10	+25
Iceland	0	3	-3
Ireland	4	0	+4
Italy	114	0	+114
Norway	38	3	+35
Poland	318	23	+295
Portugal	0	0	0
Romania	96	40	+56
Slovenia	0	1	-1
Spain	12	0	+12
Sweden	153	53	+100
Switzerland	5	0	+5
Turkey	53	84	-29
Yugoslavia	75	0	+75
Baltic Countries and the CIS States	3274	1801	+1473
Total	5432	2172	+3260

Lead fall-out in European Russia in 1991 equaled approximately 16,000 tons, of which Russia itself was responsible for 10,000 tons. Owing to the primarily western and southwestern direction of winds, lead from almost all European countries was present in Russia, including from the former republics of the USSR. Moreover, for the overwhelming majority of European countries, the introduction of lead into European Russia was greater than the corresponding transmission in the opposite direction. As a whole, because of the cross-border transmission into the territory of European Russia, in 1991, more than 3,000 tons of lead was introduced from abroad.

Because of security restrictions on access to information, such calculations cannot be performed for the Asian part of Russia. However, preliminary estimates indicate that lead introduced from China into eastern Siberia and the Russian Far East, as well as from Kazakhstan into the southern part of western Siberia is approximately equal to 2,500-3,000 tons. Here the balance of cross-border transmissions of lead is also positive.

The approximate amount of total lead introduced into the territory of Russia as a result of cross-border transmission may equal about 5,000-6,000 tons/year.

The lead content in atmospheric precipitation varies across the territory of Russia from 0.05 to 7.3 mcg/l (average annual values for the 38 years during which measurements have been taken). The highest contamination of precipitation by lead is observed in the north-west, central, and southern regions of European Russia (4.5-7.3 mcg/l).

In the non-industrial regions of the Republic of Sakha (Iakutia), Magadan Oblast, as well as in the Russian sector of the Arctic, the lowest amounts of this indicator are recorded for the whole of Russia (0.05-0.3 mcg/l).

The maximum lead content in atmospheric precipitation is recorded in the winter, which is a result of the higher level of air pollution during that period.

Lead contamination of precipitation in cities and industrial centers significantly (by up to 10 times) exceeds corresponding data received from the background regions.

The maximum lead fall-out is recorded in the north-western, central, and southern regions of European Russia (2.9-4.6 kg/km^2), which exceeds by 10-100 times the corresponding values observed in the arctic regions of Russia, the Republic of Sakha (Iakutia), and Magadan Oblast.

On the basis of geographical information and global dispersion data, as well as knowledge of the introduction of lead with atmospheric precipitation into various regions of Russia, it can be concluded that the background lead concentration in atmospheric precipitation equals 0.3-4.4 mcg/l, with an average of 2.5 mcg/l. Correlating these concentrations with both the amounts of atmospheric fall-out in certain regions and the total areas of those regions, it can be estimated that natural background sources are responsible for the introduction of about 17,000 tons of lead into the territory of Russia as a whole.

Generalization of data from measurements of the snow cover, taken by the pollution monitoring system, make it possible to determine the flow of lead on the underlying surface, which amounts to 0.5-20 kg/km^2/year for most regions of Russia (Figure 7).

Observation results testify to the zonal character of the dense fall-out dispersion (loads) of lead on the surface. The minimal level of the loads is characteristic for the northern and north-eastern regions (0.05-1 kg/km^2/year). A moderate load level (1-3 kg/km^2/year) is recorded in the western regions of Russia, the central zone of Siberia, Baikal, the banks of the Okhotsk Sea, and in Primorye. Heightened load levels of lead (3-5 kg/km^2/year) are characteristic of the Urals region, the south of Siberia, Khabarovsk Krai, Sakhalin, and Kamchatka.

In European Russia, the highest loads are seen in Moscow, Vladimir, Gorkii, Riazan, Tula, and Leningrad Oblasts, as well as the industrial center of Taganrog--Shakhty--Rostov-on-Don. Figure 8 depicts territories where the lead fall-out significantly exceeds the calculated values of critical loads for surface ecosystems.

Local anomalies of high lead fall-out (30-600 kg/km^2/year) are noted for territories located near major centers of ferrous and non-ferrous metallurgy. The zones of influence of such centers can be up to several hundred square kilometers.

Territories located near cities with other sources of atmospheric lead pollution are characterized by load values from 5 to 20 kg/km^2/year.

On the whole on Russian territory, approximately 30,000 tons of lead fall out annually. That total includes:

- fall-out due to natural sources of lead (background)--approximately 17,000 tons;
- fall-out due to cross-border transmission of lead--approximately 6,000 tons;
- fall-out due to Russian industrial sources--approximately 7,000 tons (see Table 1).

1.2.2. Surface Waters

Lead in river waters is present both as suspended particles and in soluble form. For most bodies of water in Russia, the concentration of lead constitutes 1.5-6.5 mcg/l, which does not exceed the sanitary norms acceptable in Russia (MPC).

The high content of lead in river waters (45-90 mcg/l) has an episodic character and, as a rule, is seen in those river ranges where emissions of lead-containing sewage water takes place from industrial enterprises (e.g., the cities of Naberezhnye Chelny, Toliatti, Samara, Syzran, and others on the Volga River--Figure 9).

Heightened lead content in water is recorded in the river basins of the Amur (10-90 mcg/l) and the Tobol and Ishim (30-40 mcg/l). Data from systematic observations carried out by the Russian Hydrometeorological Service in the basins of the Don, Northern Dvina, Neva, Enisei, Ob, and Irtysha testify to a moderate level of lead pollution in these rivers.

1.2.3. The Layers of the Earth

Heightened concentrations of lead in soil and plants is frequently a result of the presence of natural geochemical anomalies in the lead content of the **lithosphere**. On the ground pollution map (see Figure 10), information is presented about territories in which anomalous content of "natural" lead in the ground along fissures in the earth's crust is most likely. That map also cites information about lead deposits and large manifestations of lead-containing ores. Figure 11 is a map of underground waters contaminated with lead.

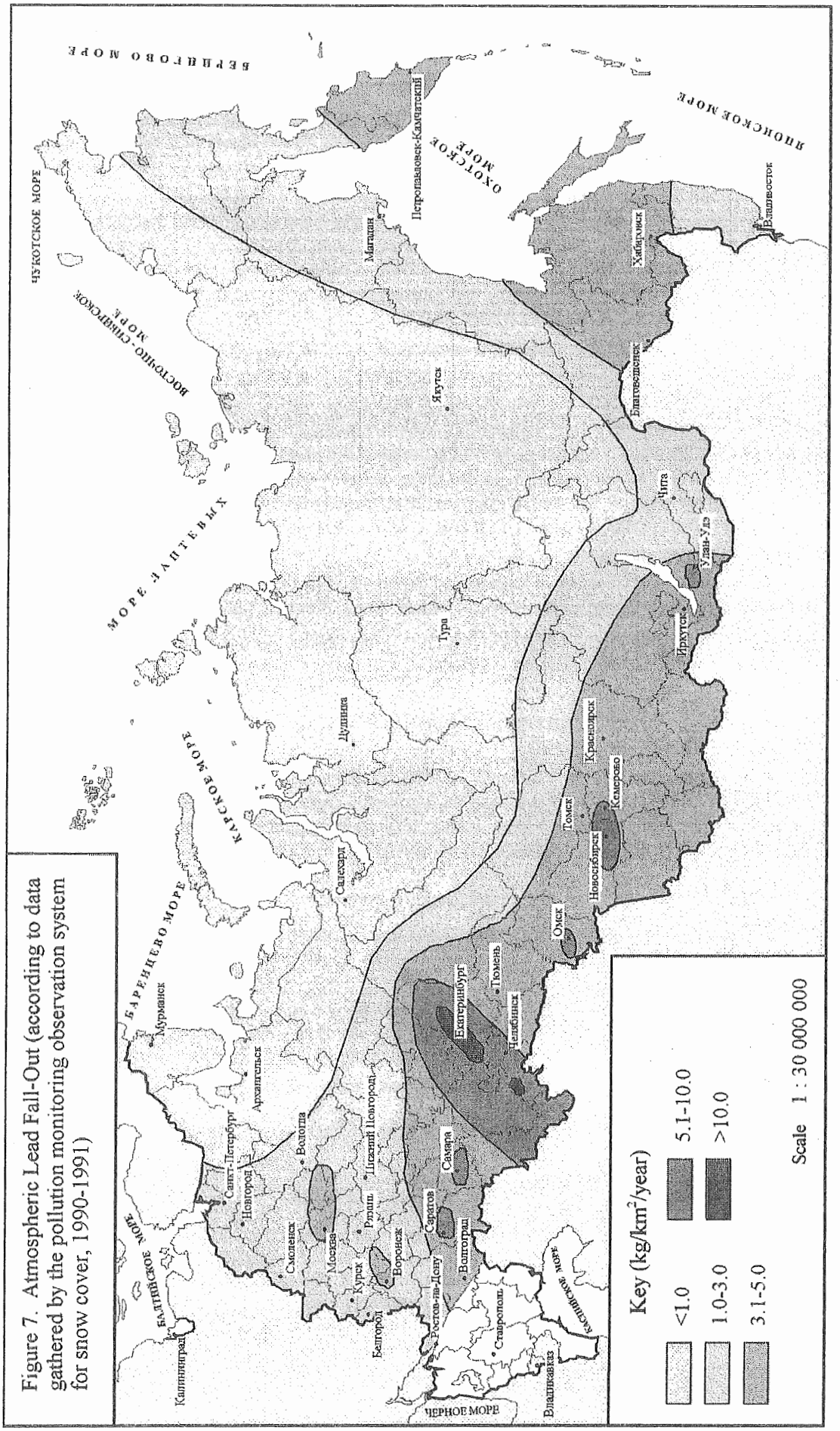


Figure 7. Atmospheric Lead Fall-Out (according to data gathered by the pollution monitoring observation system for snow cover, 1990-1991)

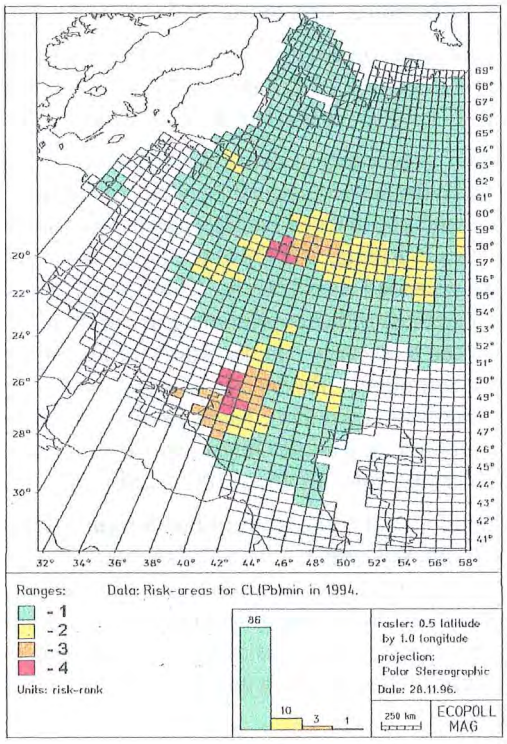


Figure 8. Assessment of European Russia lead contamination risk. Critical loads excess: 1 - no excess, 2 - low, 3 - moderate, 4 - high excess.

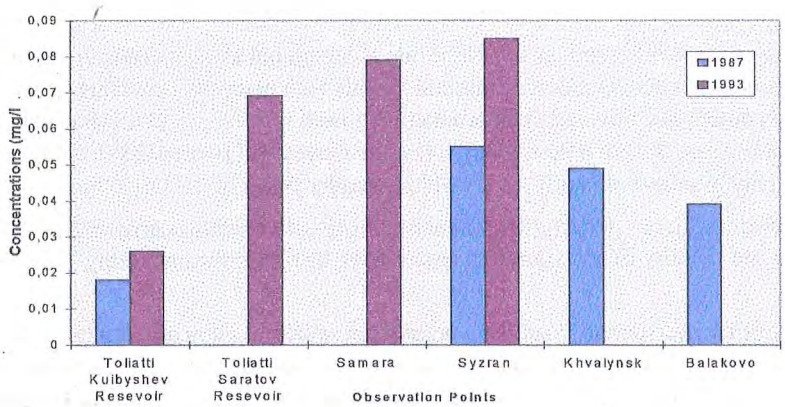


Figure 9. Maximum concentrations of lead in the water of the Volga River.

Taking into account the zones indicated on the territory of Russia, three megaregions or megazones can be picked out: the European part of the country with established and possible intensive contaminations of underground water by lead, primarily from technogenic sources; the south of Siberia and Primorye with possible, but more rarely established, contamination of underground water from mixed natural and technogenic sources; and the north-east of Siberia, primarily with supposed lead contamination of underground waters as a result of natural sources.

What attracts the attention is the contamination of water intakes in the European part of Russia, which then tapers off to the east of the Urals (Norilsk, Novokuznetsk, Baikal, Komsomolsk-on-Amur, Magadan, Petropavlovsk-Kamchatskii).

1.2.4. Soil

As the results of agricultural-environmental monitoring by the agrochemical service of Russia have proven, the degree of lead contamination of **agricultural area soils** is relatively low (Figure 10). The average content of all forms of lead in sandy and partially sandy soils equals 6.8+/-0.6 mg/kg, in soils of clayey and partially clayey granulometric content, which have an acidic reaction to their environment (pH content < 5.5), are 9.6+/-0.5

mg/kg. The same soils, which have a reaction to their environment closer to neutral (pH >5.5), are 12.0+/-0.3 mg/kg, which testifies to the accumulation of all forms of lead in soils with a heightened silt and clay fraction.

An excess of the approximate permissible concentrations (APC) for lead content was discovered only on one bench-marked allotment in Moscow Oblast. An excess of the level 0.5 of the APC has been found in a series of bench-marked allotments in the Republic of Tuva, Vologod Oblast, and Karachaev-Cherkessk Republic.

The lead content of **soils in populated areas** is significantly higher. According to data collected over the course of 20 years of research by the network laboratories of the Russian Hydrometeorological Service, the highest levels of lead content in soil are found in a five-kilometer zone around non-ferrous metallurgical enterprises. From information presented on the map (see Figure 10) of 120 cities in Russia, in 80% of the cases, the approximate permissible concentrations of lead content in soil are exceeded significantly. More than 10 million urban residents are in contact with soil that has, on average, lead in excess of the approximate permissible concentrations. The populations of a whole series of cities is exposed to average concentrations of lead in soil, exceeding by more than 10 times the approximate permissible concentrations: Revda and Kirovgrad in Sverdlovsk Oblast; Rudnaia pristan, Dalnegorsk, and Vladivostok in Primorskii Krai; Komsomolsk-on-Amur in Khabarovsk Krai; Belovo in Kemerovo Oblast; Svirsk and Cheremkhovo in Irkutsk Oblast, etc. In most cities the lead content varies within a range of 30-150 mcg/kg, with an average value of about 100 mcg/kg.

Many cities, having a "favorable" overall picture of lead contamination, are highly polluted on a significant part of their territories. For example, in Moscow lead concentrations in the soil vary from 8 to 2,000 mg/kg. The soil most contaminated by lead is located in the central part of the city, within the borders of the railroad ring and in proximity to it. More than 86 km^2 (8%) of the city is contaminated with lead in amounts that exceed the approximate permissible concentrations. As a rule, it is in these very same places that other toxic substances also exceed the maximum permissible concentrations (cadmium, zinc, copper), which aggravates the situation significantly because of the synergetic interaction of these elements.

1.2.5. Vegetation and Animals

The increase in the lead content of the soil, as a general rule although not always, leads to a growth of its concentration in **plants** both in uncontaminated soils and in soils with naturally occurring geochemical anomalies. Consequently, the lead content in cultivated plant production, raised in soil of light mechanical composition (sandy and partially sandy) varies from 0.13 to 0.96 mg/kg; in heavily clayey soil (with a pH<5.5) from 0.22 to 0.96 mg/kg; and in heavily clayey soils (with a pH > 5.5) within broader limits of 0.34 to 7.0 mg/kg.

A higher lead concentration (up to 1,000 mg/kg) is characteristic of vegetation growing in technogenically polluted territories: in the vicinity of metallurgical enterprises, of mines for extracting polymetals, and primarily along highways.

The size of the zones of *autotransport influence* on ecosystems varies widely and the breadth of roadside anomalies of lead content in soil may reach 100-150 m. Forest zones along roadways contain within the heights of the trees lead flows from vehicles. In urban conditions, the size of the lead anomalies is determined by construction and the structure of wooded areas. In dry weather lead accumulates on the surface of vegetation; after heavy rain a significant part of it (up to a half) washes off.

In soil that has been contaminated with lead it is safer to grow grains. The cultivation of vegetables, corn for silage, and feed grasses in these zones can be risky.

The accumulation of lead in **animals** depends on a variety of factors and, mainly, on their taxonomic properties. What has been confirmed is the direct dependence between the level of lead contamination in the air and its degree of accumulation in the organisms of warm-blooded animals inhabiting areas near metallurgical factories.

In invertebrates that have hard shells, that is where the lead concentrates to the greatest degree (for example, in the shells of mollusks). In vertebrates, lead concentrates mainly in the bone, in fish--in the gonads, in birds--in the wings, and in mammals--in the brain and liver.

Systematic studies of the content of lead in animals have not been carried out in Russia.

Figure 10 ⇒

СВИНЕЦ В ПОЧВАХ РОССИЙСКОЙ ФЕДЕРАЦИИ
LEAD DISTRIBUTION IN SOIL OF RUSSIAN FEDERATION

Содержание свинца в почвах вне населенных пунктов
Lead concentration in soils out of populated areas

0 10 20 30 40 50 мг/кг mg/kg

Содержание свинца в почвах населенных пунктов
Lead concentration in soils within of populated areas

0 10 32 64 160 320 1800 мг/кг mg/kg

⊙ города, систематизированные данные по которым отсутствуют
cities, systematized data on which not available

Территории, в пределах которых наиболее вероятно природное аномальное содержание свинца в почвах вдоль разломов земной коры
Areas with a possible abnormal concentration of nature lead in soil along faults

Месторождения свинца
Lead deposits

Граница Российской Федерации
Border of Russian Federation

Границы субъектов Российской Федерации
Borders of the subjects of Russian Federation

Цифрами на карте обозначены населённые пункты:

The following populated areas are indicated by figures on the map:

1 - Ангарск
2 - Арсеньев
3 - Артем
4 - Балашиха
5 - Бердск
6 - Березовский
7 - Большой Камень
8 - Верх-Нейвинск
9 - Видное
10 - Владимир
11 - Выкса
12 - Глубокое
13 - Гремячево
14 - Дальнегорск
15 - Дзержинск
16 - Дмитров
17 - Заволжье
18 - Звенигород
19 - Златоуст
20 - Иваново
21 - Иркутск
22 - Искитим
23 - Истра
24 - Каваперово
25 - Карабаш
26 - Кингисепп
27 - Кировград
28 - Кондрово
29 - Кстово
30 - Пинево
31 - Листвянка
32 - Люберцы
33 - Людиново
34 - Наро-Фоминск
35 - Находка
36 - Нижний Новгород
37 - Нижний Тагил
38 - Новокуйбышевск
39 - Партизанск
40 - Подольск
41 - Полевской
42 - Прокопьевск
43 - Пушкино
44 - Раменское
45 - Ревда
46 - Сланцы
47 - Усолье-Сибирское
48 - Уссурийск
49 - Хрустальный
50 - Шелихов
51 - Щелково
52 - Электросталь
53 - Ярославка
54 - Ярославль
55 - Ярославский

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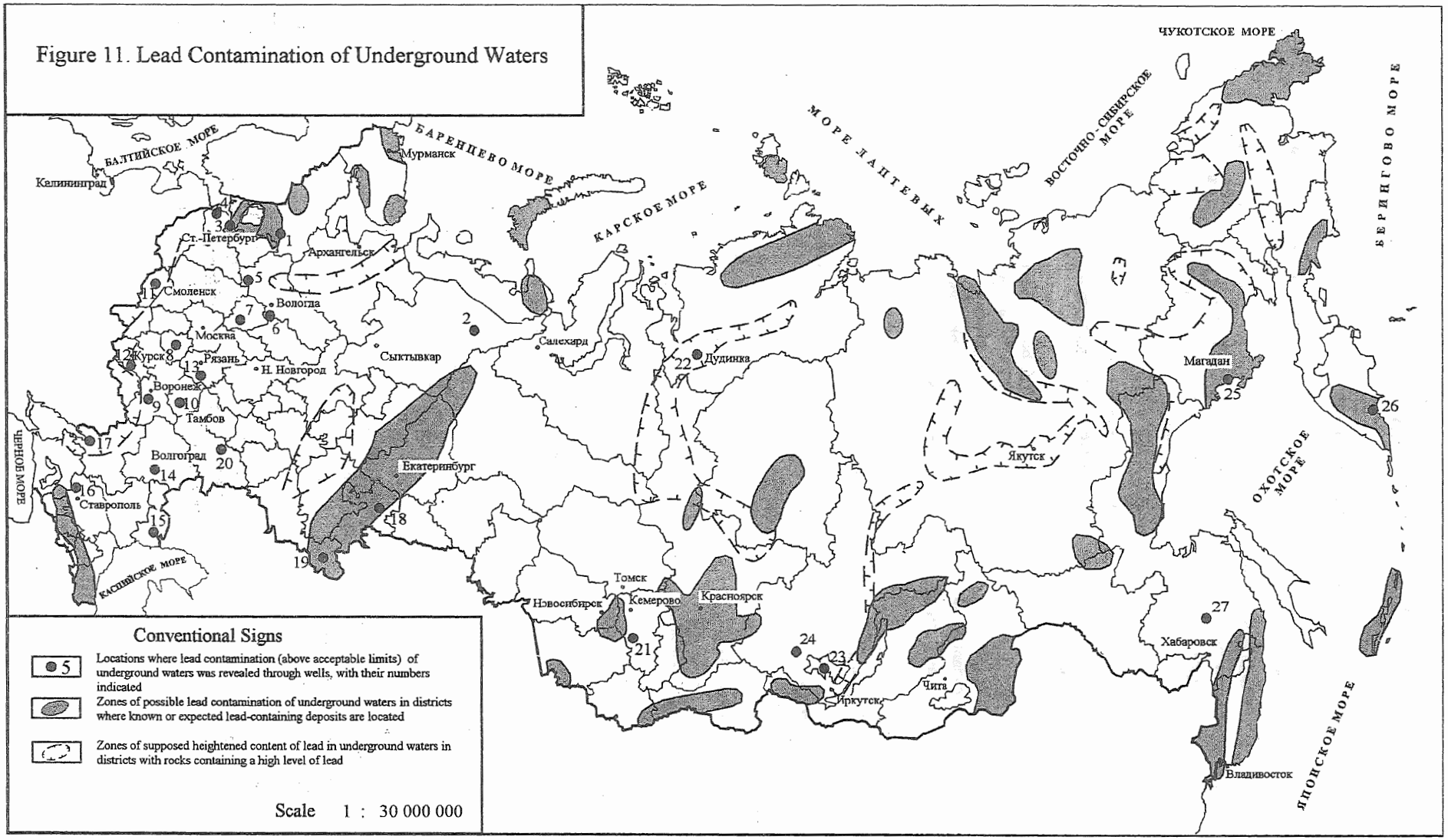
Figure 11. Lead Contamination of Underground Waters



2. THE EFFECTS OF LEAD ON HUMAN HEALTH

2.1. Ways for Lead to Enter the Human Organism

According to its degree of influence on living organisms, lead is categorized in the class of highly dangerous substances, together with arsenic, cadmium, mercury, selenium, zinc, fluorine, and benzopyrene [GOST 17.4.1.02-83].

The danger of lead for human beings is its significant toxicity and ability to accumulate in the organism. Lead's toxicity depends on its chemical form: the less toxic stearate of lead; toxic salts of inorganic acids (lead chloride, lead sulfate, etc.); and highly toxic alkalinized compounds, in particular, tetraethyllead. However, in practice, as a rule, all that is analyzed is the general content of lead in various components of the environment, raw foodstuffs, and food products, without fractional differentiation and the identification of the form of the compound.

Most lead enters the human organism through food (from 40 to 70% in different countries and according to different age groups) as well as through drinking water, air, through smoking, and through the accidental ingestion of pieces of lead paint and contaminated soil.

An insignificant amount of lead enter with the *air*--only 1-2%, but it is here that a large part of lead can be absorbed into the human organism. In the air of a majority of cities where the Russian Hydrometeorological Service monitors for the presence of lead, average annual concentrations vary within the limits of 0.01 to 0.05 mcg/m^3, which is significantly lower than the maximum permissible concentration of 0.3 mcg/m^3. Approximately as many as 44 million people live in these conditions. About 10 million people live in cities with a higher concentration of lead, i.e., 0.1-0.2 mcg/m^3.

Higher concentrations of lead in the air have been detected while carrying out specialized research in cities with heavy industrial sources that emit lead: Belovo, Vladikavkaz, Verkhniaia Pyshma, Gus-Khrustalnyi, Ekaterinburg, Karabash, Kirovgrad, Krasnouralsk, Kursk, Novosibirsk, Revda, Usole-Sibirskoe, and others. Approximately 2.5 million people live in these cities. The amount of lead in the air of these cities exceeds the maximum permissible concentration by several times.

The concentration of lead in *drinking water* in different countries of the world varies within 1-60 mcg/l and in most European countries, does not exceed 20 mcg/l. In Russia, information about lead content is exceedingly rare. In Moscow drinking water its presence varies from 0.7-4 mcg/l. It is possible that a problem with contaminated drinking water exists in places where smelting factories or storage areas for industrial wastes with high lead content are located.

Lead contamination of *soil* is one of the ways that it enters raw foodstuffs and, indirectly, into the human organism, especially of children. The highest concentrations of lead are found in the soil of cities where enterprises that smelt lead or produce lead-containing car batteries or glass are located (e.g., Belovo, Vladikavkaz, Dalnegorsk, Saransk, Rudnaia pristan, Svirsk, and several others).

Lead can enter *raw foodstuffs and food products* from the soil, water, air, and feed for agricultural animals that are part of the food chain. In addition, direct contamination during the production of finished articles is also important. The highest levels of lead content have been recorded in tin can packaging, fresh and frozen fish, wheat bran, gelatin, mollusks, and shellfish. A high lead content is seen in root plants and other harvested foods that are cultivated on land that is located nearby industrial areas and along roadways.

The contamination of food in tin cans is a result of the fact that the solder used to weld the seams contains up to 60% lead and the protective covering that is used does not hold out in this "aggressive" situation.

According to data on the consumption of food in the Russian Federation based on inspections of family budgets, it has been established that the average amount of lead being introduced into the individual organism per year equals 65.25 mg, or 1.25 mg per person each week. In certain industrial cities this rate is somewhat higher: 10% of the investigated population exceeds 2 mg/person each week. In the daily rations of children aged 1-3, the consumption of lead equals 14 mcg; from 4-6 years of age--64 mcg; and from 14-17 years of age--87 mcg, i.e., the intake of lead with food for children under 7 years old varies depending upon age within the limits of 14-68 mcg/day (see Table 4).

2.2. High Risk Population Groups

2.2.1. The Adult Population

In Russia the number of groups that have professional contact with lead is increasing. According to data from the Russian informational-analytical center State Committee for Epidemiological and Sanitary Inspection, cases of chronic lead intoxication have been recorded now in 14 branches of industry in Russia.

Leaders in the number of cases of "saturnism" are the electro-technical industry (production of car batteries), instrument building, the printing trade, and non-ferrous metallurgy. In the electro-technical, non-ferrous metallurgy, and machine building industries, intoxication was a result of lead in the air of the working area exceeding the maximum permissible concentrations by more than 20 times (Table 3). A high proportion of lead intoxications in the printing trade were caused by the use of outdated equipment in printing offices in certain regions of Russia (Amur and Penza Oblasts, for example), manual casting and smelting of lead type, and manual type-setting in areas with improper intake-exhaust ventilation.

According to the results of official statistics, among types of professional intoxication, lead intoxication holds first place. Thus, in 1994, among all acute and chronic professional poisonings, the proportion of lead intoxication constituted 11.7%. The number of victims was 7.5 for each 10,000 workers, of which 3.54 were no longer able to work. The proportion of lead intoxication in the structure of professional poisonings diagnosed in Russia has risen from 9.4% in 1991 to 11.6% in 1995.

Among workers that have suffered from the effects of lead, approximately 40% are women. For women, lead presents a special danger since this element is capable of penetrating the placenta and accumulating in breast milk. The WHO has made note of the possible risk of spontaneous abortion when the concentration of lead in the blood of pregnant workers reaches 30 mcg/dl and of an increase in the number of chromosomal aberrations among workers with levels of lead in the blood higher than 80 mcg/dl.

Table 3.

Number of Enterprises Among Industries in Russia Where the Amount of Lead in the Air of Working Areas Exceeds Maximum Permissible Concentrations

Excess of MAC (in multiples)	Branches of Industry			
	Non-Ferrous Metallurgy	Electro-Technical Industry	Equipment and Machine Building	Printing Industry
6-10	-	-	2	4
20-50	6	8	-	-
50-100	2	14	-	-
over 100	-	10	-	-

2.2.2. Lead and Children's Health

The main indicator of the effect of lead on the health of children is *the level of its content in the blood*, despite the constant reconsiderations of the recommended standard lead content for blood. The results of a series of major international and national projects have confirmed that heightened concentrations of 10-20 mcg/dl of lead in the blood of children cause a decrease in IQ levels.

In Russia, research on the determination of lead content in the blood of children is exceedingly little, but the results obtained testify to its being heightened in the blood of children living near car battery factories in St. Petersburg and metallurgical plants in the cities of Belovo, Karabash, and Krasnouralsk.

The permissible level of lead in hair is 8-9 mcg/g. Systematic research to determine the accumulation of lead in human hair has been carried out in various Russian cities since 1980 using modern instrumentation. During the last 15 years, research has been done on about 5 thousand types of hair from children living in cities with various sources of lead discharges. Among the juvenile population exposed to increased concentrations of lead, the highest accumulation levels have been seen in areas next to metallurgical and car battery factories in the cities of Vladikavkaz, Kursk, Karabash, Krasnouralsk, Kyshtym, Saratov, Cheliabinsk, as well as the zone of influence around Chernobyl.

A significant accumulation of lead has been found in the teeth of children living in the Urals cities of Karabash, Kirovgrad, Krasnouralsk, Verkh-Neivinsk, and Verkhniaia Pyshma. The levels of lead in these children's teeth is significantly higher than that of children in the U.S. and other countries.

The influence of lead on children's health is examined below in the individual systems of the organism, where this metal has more pronounced effects.

Neurological Effects. Changes in the psychomotor reactions of small children are connected to increased amounts of lead entering the system when children put in their mouths hands or toys that have touched contaminated soil. For school-aged children, it is characteristic that the IQ indicator changes. The influence of lead is seen as well in changes in physical activity, coordination, the motor-optical and -acoustic reaction periods, hearing, and memory. These changes in the psychoneurological condition of a child may also appear at older ages, which is manifested in learning difficulties and obstacles upon entering high school.

The most pronounced changes in the psychoneurological condition of children are seen in those living near the car battery factories in the cities of St. Petersburg and Saratov, and the metallurgical factories in the cities of Belovo and Krasnouralsk. In Belovo (the average content of lead in the blood of children is 9.9+/-0.5 mkg/dl), anxiety among children is greater than in other locations. Diseases of the nervous system among newborn children in this city are primarily encephalopathy and convulsive syndrome; for older children neuroses, aneurysms, and epileptic syndromes. In Krasnouralsk (the average content of lead in the blood of children is 13.1+/-0.5 mgd/dl) 76% of children exhibit a lag in mental development.

During the long-term presence of lead in the system *nephrological effects* also appear. Among children of pre-school age living near the Saransk electric light factory, which is a source of lead and mercury contamination, the prevalence of disease in the urinary system is three times higher than in a control area of the same city.

Lead causes certain changes in the *cardiovascular system.* The pathogenesis of heart lesions caused by lead is connected with lesions of the mitochondria, in particular, with the inhibition of calcium ion absorption. Children with increased amounts of lead in their blood (more than 20 mcg/dl), who live near the car battery factory in St. Petersburg, have exhibited functional changes within the cardiovascular system.

Lead pollution influences the health of newborns. Newborns in the cities of Belovo in Kemerovo Oblast and in Karabash in Cheliabinsk Oblast exhibit lower levels of physical development than those in the control area. In another city with a metallurgical factory, Vladikavkaz, women experience higher frequencies of infertility, spontaneous abortions, toxicoses, still births, and births of children with congenital defects in the development of the skeletal system, the heart, etc. The number of children with birth defects is higher among those whose parents work at the metallurgical plant. In this same city among workers of smelting production an increase in the number of chromosomal aberrations is exhibited.

The *integrated biokinetic model of lead intake into children's organisms* makes it possible to estimate for the juvenile population the probability of lead concentration distributions in the blood, based on information available about how lead enters the organism. *Risk* is considered the probability that lead concentrations in children's blood will exceed standard levels, which are taken here to be the U.S. official medical norms for lead content in the blood of children (CDC scale), since in Russia analogous standards have not been set.

To estimate risk, calculations were done on the general indicators for lead content in various parts of the environment and in food. On the basis of the material noted above, Russian cities (more than 150 cities were analyzed) were divided into two groups: (1) those with relatively low or moderate levels and (2) those with high levels of lead occurring in the environment.

Calculations on ways for lead to enter the systems of children living in Russian cities point to the predominant roll of food sources, which account for more than 85% of the overall intake of lead into the organism (Table 4). However, data on the contamination of foodstuffs used for feeding children in Russia are highly contradictory. Therefore, additional analysis of the lead content in food products is necessary.

Table 4.

Routes for the Daily Intake of Lead into the Organisms of Preschool Children in Russian Cities

Characteristics of Cities	General Intake (mcg/day)	Sources of Lead Intake into the Organism (%)			
		Air	Drinking Water	Soil and Dust	Food
Cities with relatively low or moderate levels of contamination	23-33	0.3	1.5	11.3	86.9
Cities with high levels of contamination	24-67	0.7	2.8	10.7	85.8

The insufficiency of available information on lead content in drinking water should also be noted. This area, without question, requires further study since the values for Moscow that were used in calculations may not

reflect the actual level of drinking water contamination in other Russian cities. A systematization of available data on lead content in drinking water in different regions of Russia must be undertaken.

The average expected lead content in the blood of children for cities with lower lead contamination is close to the control standard--10 mcg/dl. In cities with greater occurrences of lead, this figure may be almost twice higher.

The results of risk calculations using the CDC scale (Table 5) testify that almost 44% of children in Russian cities may have behavioral and learning difficulties as a result of the influence of lead; approximately 9% require treatment; the health of 0.2% of these children is in danger; and about 0.1% of children (500 of the group that was analyzed) need to receive immediate medical intervention.

Table 5.

Prognosis of the Number of Children with High Levels of Lead in the Blood (expressed in millions)

Characteristics of Cities	Children Under 7 Years (millions)				
	Total	Lead Content in Blood (mcg/dl)			
		10-19	20-44	45-69	>70
Cities with relatively low or moderate contamination levels	4.3	1.8	0.3	0.003	0.0
Cities with high levels of contamination	0.2	0.1	0.1	0.006	0.0005
Total	4.5	1.9	0.4	0.009	0.0005

3. LEGAL, REGULATORY, ECONOMIC, AND INSTITUTIONAL MEANS OF SOLVING THE PROBLEM OF LEAD CONTAMINATION OF THE ENVIRONMENT

3.1. Legal, Regulatory, and Economic Basis

The legal protection of the environment and human health from polluting substances is carried out by several branches of law: constitutional, civil, criminal, administrative, medical, environmental, natural resources, as well as regulatory legal documents and international conventions and agreements that have been ratified by Russia.

The Russian Constitution guarantees the right of every citizen to a clean environment, reliable information on its condition, and compensation for damaged suffered to health or property as a result of environmental infringements.

The foundations of the law of the Russian Federation on the preservation of citizens' health of July 22, 1993, in addition to regulating administrative relations, also guarantees the environmental rights of citizens: the right to the preservation of citizens' health and the right to information about factors that effect health. Especially secure are the rights of citizens to good health in unfavorable areas and the right to appeal the actions of government organs and officials in the area of health preservation.

The law of the Russian Federation "*On the sanitary-epidemiological well-being of the population*" of April 19, 1991 regulates the guarantee of a good state of health within peoples' living environment (working conditions, studies, way of life, rest, residence, etc.), where dangerous and harmful influences on the organism are absent, and also establishes propitious conditions for life's work. The basic responsibility for this is placed on the Government in the person of the legislative and executive branches. However, the law also proceeds from the idea that securing the sanitary-epidemiological well-being of the population is a component of the governing, social, and productive activities of all government organs, enterprises, and public associations.

The law places responsibility on enterprises to ensure the existence of productive, sanitary, and environmental controls in order to prevent the contamination of the environment, guarantee safe working conditions, the production of goods that do not cause harm to human health, etc.

The law of the Russian Federation "*On consumer rights*" of February 7, 1992 guarantees consumers that goods, work, and services under normal conditions of use and during transport and storage are safe for life, health, and the environment, and establishes liability for harm done as a result of defects in the article (work, services).

The system of environmental law is headed by the *Law of the RSFSR "On the preservation of the environment"* of December 19, 1991. For the first time in the history of Russian legislation, citizens are given the right to the preservation of health from unfavorable environmental effects that result from economic or other activities, accidents, catastrophes, and natural disasters. Enterprises, institutions, organizations, and individuals that cause harm to the environment, health, and property of citizens or the economy by contamination of the environment through damage, destruction, injury, non-rational use of resources, destruction of natural ecological systems, and other environmental offenses must provide full compensation.

The federal law *"On environmental analysis"* of July 19, 1995 is designed to implement the constitutional right of Russian citizens to a healthy environment by *preventing* the negative effects of economic and other activities on the environment.

The law of the Russian Federation *"On the fundamentals of urban development in Russia"* of July 14, 1992 establishes the purposeful activities of the Government in the formation of favorable living areas and stipulates the basic objectives of urban development activities: its organization with consideration for the condition of the environment; the environmentally safe development of cities, other settlements, and their systems, so that the rights of citizens to good health and harmonious physical and spiritual development is secured; and the rational use of the land, the preservation of nature, the conservation of resources, and the defense of areas from dangerous technogenic processes.

The basic legislative act regulating the terms of *water use and the preservation of bodies of water* is the *Water Code* of the Russian Federation of October 18, 1995.

In the Russian Federation in effect to the present day is the law of the RSFSR *"On the protection of air"* of July 14, 1982, which in many ways contradicts the new Russian environmental conservation legislation and cannot be a means for solving the problems of air pollution in Russia.

The *Land Code* of the Russian Federation sets as its task the regulation of land relations with the goal of rational use of land and its preservation, the reproduction of soil fertility, and the preservation and improvement of the natural environment. The notion of land preservation includes the defense of the land from polluting wastes from industrial production and chemical substances.

Individual aspects of the protection of the environment and human health are reflected in the federal laws of the Russian Federation "The fundamentals of forest legislation of the Russian Federation," "On the animal kingdom," "On specially protected nature territories," "On the continental shelf," "On land improvement," "On natural medicinal resources, medicinal-health localities, and health resorts."

The *Administrative Code* of the Russian Federation establishes administrative responsibility for various infringements in the area of environmental protection: exceeding norms for maximum permissible concentrations or for temporarily permissible discharges of pollutants into the atmosphere; exceeding the norms for maximum permissible concentrations of physical influences on the air; discharges of pollutants into the atmosphere without approval from government organs specifically empowered for that purpose, etc.

The *Criminal Code* of the Russian Federation, approved on June 13, 1996 and coming into effect on January 1, 1997, oversees criminal liability for environmental crimes.

The Constitution of the Russian Federation establishes that "the generally accepted principles and norms of international law and the international agreements of the Russian Federation are a constituent part of the legal system. If the international agreements of the Russian Federation establish a rule that differs from that of the law, the rule of the international agreement is applied."

To the number of most important *international agreements* ratified by Russia belongs the *Convention on Long-Range Cross-Border Air Pollution* (1979) and the *Basel Convention on the Control of Cross-Border Movement of Hazardous Wastes and Their Disposal* (1989). In correspondence with the law "On the ratification of the Basel Convention on the Control of Cross-Border Movement of Hazardous Wastes and Their Disposal" of November 25, 1994, the resolution of the Russian Government of July 1, 1995, No. 670, "On priority measures for the fulfillment of the federal law "On the ratification of the Basel Convention on the Control of Cross-Border Movement of Hazardous Wastes and Their Disposal," and the resolution of the Russian Government of July 1, 1996, No. 766, "On government regulation and control of cross-border movement of hazardous freight," which was affirmed by the Statute on government regulation of Cross-Border movement of hazardous wastes, Russia prohibited the import and transit of wastes containing lead compounds and placed under government regulation the Cross-Border movement of lead, lead dross, lead slurry, and lead-containing wastes for the purposes of removal, as well as the export of wastes that contain lead compounds.

On the basis of numerous ***regulatory documents*** lie concrete standards that limit the content of lead and lead compounds in certain environmental objects, in raw materials and raw foodstuffs, in food, and in industrial wastes: MPC, ASLI, APC, PRA, PDD, and other biological criteria.

In particular, for lead a maximum permissible concentration of 0.3 mcg/m^3 is set for *air,* 10 mcg/m^3 for working areas; and 30 mcg/l for *drinking water*. For *soils* a maximum permissible concentration is set for the total content of lead (Sanitary Rules and Norms 42-128--4433-87) and an approximate permissible concentration of lead depending on the mechanical make-up and acidity from 32 to 130 mg/kg (hygienic norms 2.1.7.020-94). The permissible residual amount of lead for *food products*: fish--1.0 mg/kg; meats and vegetables--0.5 mg/kg; fruits and juices--0.4 mg/kg; bread and grain--0.2 mg/kg; and milk products--0.05 mg/kg.

Materials on the prevention of effects from the discharges from autotransport that runs on leaded gasolines appeared almost fifty years ago. In 1947 the All-Union Government Sanitary Inspectorate approved the "Rights for the storage, transport, and use of leaded gasoline." In 1948, the "Temporary sanitary rules for the storage, transport, and use of liquid ethylene as an additive for aviation and automotive gasolines in the capacity of an antiknock agent" and in 1972 the "Rules for the storage, transport, and use of leaded gasolines in autotransport" were approved by the Main Government Sanitary Inspectorate of the USSR. On the basis of an instruction from the Council of Ministers of the USSR on January 28, 1956, the use of leaded gasolines was prohibited by the Main Sanitary Doctor of the USSR in Moscow, Leningrad, the capitals of the union republics, and in health resort areas. With the same goal, measures were passed to ensure the production of unleaded gasolines in oil refineries in Moscow, Kirishi, Krasnodar, and Tuapse.

In 1991, the Supreme Soviet of the USSR ratified the Convention of the International Organization of Labor No. 13 "On the use of white lead in house painting." The statutes of this Convention are reflected earlier in such documents as the Resolution of the People's Committee of Labor of the USSR of August 16, 1929, No. 265 "On the preparation, sale, and use of white lead," "Sanitary rules for painting with the use of hand sprayers No. 991-72," and GOST 12.3.O35-84 SSBT. "Painting work. Safety requirements."

In correspondence with the Land Code of the Russian Federation, the Statute was adopted by a decision of the Russian Government on August 5, 1992, No. 555, "Statute on the procedure for conserving degraded agricultural lands and land contaminated with toxic industrial wastes and radioactive substances," in accordance with which land that is contaminated with toxic industrial wastes above the maximum permissible concentrations will be subject to conservation for the restoration of its fertility and subsequent rehabilitation.

At the present time work is coming to a close on the preparation of "Sanitary rules and norms for work with lead."

In the case of a violation of the sanitary rules and norms, measures are undertaken by the State Sanitary and Epidemiological Service to lower the influence of discharges of harmful substances and lead, in particular on the state of human health. For example, production was brought to a stop at the Karabash Metallurgical Plant in 1992, at the Podolsk Car Battery Plant in 1994, and at the Saratov Plant in 1994.

In correspondence with the Law of the Russian Federation, "On the Preservation of the Environment," the basic ***economic methods*** for regulating the preservation of the environment are land surveys of natural resources, environmental programs, fines for polluting the environment, licensing, and economic stimulation. These economic methods, which form the economic mechanism of natural resources use, have exhibited a varying degree of application in practice. To the greatest extent, it is the system of fines for polluting the environment, which was developed and has been functioning successfully since 1991.

It is necessary to note that, at the present time, within the economic mechanism of natural resources use special measures are lacking that would be aimed toward the reduction of lead contamination. However, in system of general economic stimuli, which are targeted toward a decrease in environmental pollution, there are elements that are indirectly focused on lowering lead contamination. They are, for the most part, tied with fines for environmental pollution.

The standard of payment is a part of the value of the annual proportional economic loss to the economy, which replaces expenses for compensation or elimination of the harmful effects of discharges (disposals, wastes) of contaminating substances, as well as expenses incurred in preventing the indicated influence by way of reaching the maximum permissible level of discharges (disposals, wastes) and of the construction of nature preservation sites.

Fines for polluting are collected from the users of natural resources (enterprises, institutes, organizations, and other legal persons) independently of their organizational-legal form and form of ownership, for the following types of influences on the environment:

discharge into the atmosphere of polluting substances from fixed and mobile sources;

disposal of polluting substances into surface and underground bodies of water, as well as any underground disposal of polluting substances;
disposal of wastes.

The base norms of payment for discharges and disposals of specific polluting substances is defined as the product of the proportionate economic loss within the limits of the permissible regulatory discharges or disposals and the indicator of the relative danger of that polluting substance for the environment and human health (Table 6). The base norms of payment for the disposal of wastes is the product of the proportionate expense for the disposal of a unit (mass) of waste of the fourth class of toxicity and the indicator that accounts for the toxicity class of the waste.

The base norms of payment for disposal of polluting substances into surface and underground bodies of water for lead:
- within the limits of permissible norms of disposal: 22,175 rub/t;
- within the established limits: 110,875 rub/t.

The base norm of payment for the burial of one ton of wastes within the established limits is 6,000 rub/t.

In the case of excessive pollution of the environment, the size of the fine increases by five times. The indexation coefficient of the base norms for fines is calculated annually; in 1996 it was set at 35.

A special procedure for calculating fines for discharges of polluting substances into the air exists for mobile sources. On the basis of its formation are the type of polluting substance, type of fuel, the base norm of payment for the discharge of one ton of the polluting substance, and the mass of the specific polluting substance, contained in exhaust gases of a technically correctable means of transport, which met the operative standards and technical conditions of the factory-manufacturer while using one ton of fuel of a specific type.

Regulatory fines for various types of fuel is set at (rub/t of fuel):
- leaded gasoline AI-93 - 38.0; A-76 - 25.0;
- unleaded gasoline AI-93 - 10.0; A-76 - 11.0;
- diesel fuel - 21.0.

Table 6.

Base regulatory payments for discharges into the atmosphere of substances from fixed and non-stationary sources (rubles/ton)

Name of Substance	Within Range of Allowable Norms for Wastes	Within Range of Established Limits
Lead and lead compounds (expressed in terms of lead)	55,000	275,000
Lead sulfide	9,705	48,525
Tetraethyllead	5,499,995	27,499,975

One of the most complicated questions if the *estimation of the amount of the damage from polluting the soil*. In 1993 a procedure was approved for defining the amount of the damage from land pollution by chemical substances. In calculating the amount of damage, indicators of the level of land pollution by chemical substances are used. For lead: level 1 (permissible) < MAC; level 2 (low) 1-3 MAC; level 3 (moderate) 3-5 MAC; level 4 (high) 5-20 MAC; and level 5 (very high) > 20 MAC. The magnitude of the MAC for lead in the soil, cited in the given method, equals in gross forms 32 mg/kg, in sliding forms 6 mg/kg of soil.

In accordance with the *Constitution of the Russian Federation* questions about the use of natural resources, the preservation of the environment, and the guarantee of environmental safety fall under the joint jurisdiction of the Russian Federation and member states of the Russian Federation. This means that **member states of the Russian Federation** have the right to pass laws and other regulatory legal acts on these issues, as long as they do not contradict the federal laws.

3.2. Environmental Monitoring and Health Screening

A plan to create and implement a *Single Government System of Environmental Monitoring* (SGSEM) has been developed by the State Committee for Environmental Protection of Russia. However, this system is still a long way from being introduced widely into environmental practice.

At the same time the *Government Service for Observing the State of the Environment* (GSO) functions in the Russian Federation as a subdivision of the Russian Hydrometeorological Service.

For an estimation of the present state, a prognosis of change in the level of environmental contamination in a region removed from anthropogenic sources of pollution by more than 100 km (background regions), the system of complex background monitoring (SCBM) was developed at the end of the 1970s in the USSR. Into the working program of the SCBM stations, which are located inside biosphere reserves, are included measurements of lead in the atmosphere. At the present time this network includes ten stations in various natural and climatic zones.

To the Russian Hydrometeorological system also belongs a network of stations for the *monitoring of air pollution in cities* which experience negative effects of industries, including those that discharge lead into the atmosphere (217 stations in 126 cities). Based on research conducted at these stations, the "Yearbooks on the state of air in cities" is prepared. The *regional stations of pollution control for snow cover, soil, and plants* also belongs to the Russian Hydrometeorological network.

Currently, *complex agroenvironmental monitoring* of the negative effects on the soil of agricultural areas is carried out by 32 centers and 71 stations of the agrochemical service, as well as 75 plant-growth protection stations that fall under the Main Committee for Chemical Protection of the Ministry of Agricultural Production of Russia.

At bench-marked allotments, the Central Institute of Agrochemical Agricultural Services conducts: agrochemical research (presence of macro and micro-elements); radiological research and the determination of degrees of heavy metal and pesticide pollution; determination of the level of the harvest and its quality; the determination of heavy metal pollution of the snowfall and rainfall.

Regional systems of environmental monitoring also function alongside the federal system. For example, in Moscow measures for the organization of environmental monitoring are being implemented. Decisions of the Executive Committee of the Moscow Council of April 25, 1989, No. 872, and of March 20, 1990, No. 452 (on the organization of activities for the development and formation of a system of environmental monitoring in Moscow), resolutions of the Moscow Government of January 28, 1992, No. 38, and of May 23, 1995, No. 436 (on progress of work on the creation of automated systems of environmental monitoring) define a mechanism for meeting a set of measures connected with the creation of a network of posts for observing the pollution of environmental sites, including by lead. A system of monitoring bodies of water is being established with that would make possible the monitoring of lead content through an automatic regime at the water preparation stations and by way of manual sample selection with subsequent laboratory analysis of drinking water within the water distribution system.

The results of *monitoring*, according to data from the State Sanitary and Epidemiological Inspection, for *lead content in raw foodstuffs and food products* as a whole in Russia indicate that for the period since 1990, the number of analyses conducted has risen by 47 times. Moreover, a decrease has been discerned in the number of research samples that do not correspond to standard requirements from 3.8% in 1988 to 2.4% in 1993. For the last three years, the number of imported food products that do not conform to hygienic regulations for lead content has also decreased: in 1993--by 2.6%; in 1994--by 0.3%; and in 1995--by 0.2%.

Medical-biological monitoring is conducted in correspondence with the Ministry of Health of the Russian Federation Order No. 90, dated March 14, 1996, for the conduct of periodical medical examinations of those individuals who work in contact with lead. In addition to looking at blood levels for lead, testing is also required for the alkalinity of urine, for hematological indicators--hemoglobin, color indicators, reticulocytes, and erythrocytes with basophilic graininess. With the use of the indicated diagnostic program together with data from examinations by therapists and neuropathologists, it is possible to detect much earlier the initial signs of the unfavorable influence of lead on workers' organisms. Of especial value in the process of medical-biological monitoring are results gained from those laboratory examinations mentioned above in group analyses of the health of specific professions.

3.3. Federal and Regional Programs

By resolution of the Government of the Russian Federation No. 263 of March 6, 1996, the *federal target program "Fuel and Energy"* was approved, the composition of which includes subprogram "Reconstruction and modernization of the oil refining industry." The program is expected to be run to the year 2000 and provides for an increase in the production of unleaded gasolines up to 65%.

This program requires a capital investment of US$12-15 billion. However, due to a limitation in investment resources, a fall in the output of oil, and other reasons, the fulfillment of the program has fallen behind by 2-3 years.

The transition to production of unleaded gasolines is held back also by the pricing policy for automotive gasolines that is developing in the country. The price of leaded gasolines is less than the price for the unleaded variant, and the taxation system is unified and does not vary based on type of gasoline.

By resolution of the Government of the Russian Federation of January 24, 1994, the *federal program "Technical re-equipping and development of metallurgy in Russia (1993-2000)"* was approved. The main priorities of the program are the competitiveness of production and a significant improvement in environmental conditions by reducing emissions of dangerous chemical substances. The program provides for the reconstruction and technical re-equipping of 143 ferrous and non-ferrous metallurgical enterprises. Work is being carried out now at 89 enterprises.

By resolution of the Government of the Russian Federation of September 13, 1996, No. 1098, the federal targeted program "Wastes" was approved.

Among urgent measures for solving the problem of wastes, including those containing lead, belong the following:

- the development of a classifier for toxic wastes;
- the carrying out of an environmental assessment of branch industry standards for technological planning, including regulations on required complex processing of raw materials, for the use, neutralization, and environmentally safe disposal of wastes;
- the creation and introduction into practice of a system of economic regulation in order to intensify the use within the economy of secondary resources.

At the level of the *member states of the Russian Federation*, a series of programs have been worked out to provide solutions to the issues of preventing lead contamination of the environment.

For example, by resolution of the Cabinet of Ministers of the Republic of Tatarstan on May 19, 1995, No. 312, "The program on decreasing discharges of polluting substances into the atmosphere from automotive sources in the Republic of Tatarstan," was approved, which provides for the development of new anti-knocking agents for motor fuels as a replacement for liquid ethylene, the development of proposals for the economic stimulation of the transition by transport to the use of natural gas and other alternative forms of fuel, the implementation by 2000 of the transition to gas by not less than 30% of all automobiles in Kazan and a number of other cities of the republic.

The Government of Moscow, by resolution No. 860 of September 27, 1994, approved the Moscow Complex Environmental Plan, which was envisaged as a program of measures to improve the condition of the environment in Moscow and, in particular, to improve the condition of air quality.

By the instruction of the Mayor of Moscow on December 1, 1993, No. 689-RM "*On the specifics of the sale of motor fuels in Moscow and the introduction of monetary sanctions,*" the retail trade of leaded gasoline was prohibited. By the resolution of the Government of Moscow on May 18, 1996, No. 517, a statue was approved on procedures governing the implementation in Moscow of environmental monitoring of automotive transport, which provided for the introduction of a standard certificate of autotransport. With the instruction of the Mayor of Moscow on August 13, 1996, No. 239/1-RM, a plan of environmental measures was approved for 1996, which provides for:

- the preparation and implementation, in stages, of measures to sell environmentally acceptable motor fuel in the Moscow region;
- the gradual installation of converters and filter-converters on municipal transport;
- a series of measures to develop and introduce alternative types of motor fuels and electric transport;
- conducting a mass operation to check the amount of exhaust discharged by cars from Moscow and from other cities (no less than 800,000 units) with the application of administrative and environmental punishments;
- the preparation, installation, and subsequent maintenance of informational billboards, to be placed at a distance of (5-50) km from the city, which say "The Use of Ethylene Gasoline in Moscow is Prohibited!" and "Entrance into Moscow with Exhaust Discharges of CO, CH, and Smoke Exceeding State Standards is Prohibited!";
- the limitation (and possible prohibition) in Moscow of vehicles of foreign manufacture produced before 1985;
- the preparation of a program to erect purification structures for surface drains on the largest water discharges into the Moscow, Iauza, Setun, Nishchenka, Chermianka, and Kotlovka Rivers;
- the preparation of a program of measures to prevent the disposal of heavy metals from primary industrial sources into the Moscow River and the sewer network

By instruction of the head of the Government of Moscow of November 10, 1996, No. 1083-RP, "On measures for the use by Moscow municipal transport of improved motor fuels" the use of measures to expose the use of leaded gas in Moscow is provided for, including to the extent of canceling the licenses of organizations that defy the law.

In general it must be noted that a coordinated government policy is still lacking in the Russian Federation that would provide for the regulatory-legal and economic regulation of the effect of lead and other heavy metals on the environment and human health, a decrease in discharges, disposals, and wastes containing lead, the processing and neutralization of wastes, and an end to the production of leaded gasolines.

In connection with this, it is imperative to determine in an expedient manner the conditions for developing and implementing the Complex Federal Targeted Scientific-Technical Program for the Protection of the Environment and Human Health from Lead Contamination, since the solution to this problem will require a combination of scientific, technical, and practical efforts.

3.4. NGO Efforts

A mass public environmental movement emerged in the Russian Federation a relatively short time ago, at the end of the 1980s. The development of the environmental movement is tied to the realization on the part of the public, official circles, and constantly growing numbers of the population of the escalation of the processes of environmental degradation as a result of human activities, from the local and regional to global levels, i.e., an understanding of the worldwide scale of the problem.

In 1996 in the Russian Federation, according to data from the State Committee for Environmental Protection in Russia, as many as 1,000 environmental NGOs were active. The legal basis for their activities is guaranteed by the federal law "On public associations," which applies also to those movements and associations that are not registered as legal entities.

Participants of the environmental movement in the Russian Federation come from practically all social categories of present-day society and have relatively high educational and intellectual levels, which may enable them to better deal with growing environmental problems and more actively attract newcomers into their ranks.

The new public organizations that emerged during the second half of the 1980s accumulated the growing dissatisfaction of society with the state of governmental environmental activities, as well as those of traditional environmental organizations. They vary in number of members from very small groups to large associations; by territorial measure, from local to national (many even have international contacts); by level of ecological problems, from local to global; by the range of their activities, from relatively narrow specializations to broad programmatic work; by their relationship to the Government, including organs of environmental protection--from those that work in collaboration to those that take antigovernment positions.

The objectives of their activity vary widely:

- the collection and dissemination of information about the environment and environmental education;
- the organization of independent public environmental assessment projects and solutions, and the creation of alternative plans and projects;
- public monitoring of the state of the environment, the quality of food products, the observation by industrial enterprises of the law, and government decision-making;
- the formation and reflection of public opinion about environmental problems;
- the carrying out and assistance with practical environmental measures and actions, their financing, organizational, and informational structures;
- assistance and conducting of scientific research on various environmental problems;
- unification and coordination of public efforts, development and assistance to contacts in this area, international collaboration and cooperation, the study and dissemination of the experience of foreign environmental movements, and countless other activities.

Environmental NGOs have given serious attention to the problem of lead and lead compound contamination of the environment. In Omsk, Perm, and Tiumen Oblasts and in Primorskii Krai about 14 NGOs are providing assistance on an initiative to transfer to the use of unleaded automotive gasoline.

Sociological research conducted by REFIA and the Institute of Socio-Political Research of the Russian Academy of Sciences indicates that a transition to unleaded gasolines or the regulation of the use of leaded:

- corresponds to the state of public opinion;
- is a clear contribution to the improvement of the environmental situation;
- corresponds to worldwide trends.

According to information from a poll among participants of the Second All-Russian Scientific-Practical Conference on the Problems of Rehabilitating Populations in Zones of Environmental Destruction (March 29, 1995), 72% of those questioned saw the problem of air pollution in Russia as exceptionally pressing and another 19% as pressing.

The most fruitful activities of environmental NGOs in terms of the problem under review consists of:

- expanding public initiatives to include a greater number of zones in which the use of leaded gasolines would be banned; to require certification of imported antiknock additives for gasoline that are sold retail; to limit the everyday use of paints, solders, and other substances containing lead;
- educational activities among the populace about lead contamination;
- the development of recommendations, jointly with environmental protection organs, for local organs of power on the organization of work with objects identified as sources of lead and lead compound contamination;
- participation in the development of national and regional programs to fight lead contamination;
- exposure of earlier unknown local sources of contamination;
- a constant effort to attract the attention of the organs of power at all levels to the need to solve the problem under consideration;
- providing civilian support to corresponding government programs;
- establishment of international contacts with the objective of applying foreign experience to the development and implementation of measures to prevent and reduce environmental contamination by lead and lead compounds.

4. THE MAIN ASPECTS OF THE PROGRAM TO LOWER THE PRESENCE OF LEAD IN THE ENVIRONMENT AND ITS DANGER TO HUMAN HEALTH

4.1. Improvement of Production Technology and Methods of Purification

The most fundamental way to protect the environment from lead contamination is to replace existing technology. Below the main efforts to lower lead contamination of the environment in various branches of industry are reviewed.

In a majority of ***ferrous and non-ferrous metallurgical*** plants measures have been planned and are already being implemented to cut sharply environmental pollution. This primarily relates to the replacement of out-of-date technology and equipment with contemporary processes that are ecologically sound and conserve resources, making it possible to curtail substantially the volume of discharged gases and to guarantee possibly a complete utilization of all components of those gases, including lead compounds.

The basic approach of the reconstruction of the copper-smelting industry was a transition to autogenous smelting technologies with the use of oxygen-enriched blasts, which, aside from their technological advantages, also make it possible to cut the volume of discharged gases. It, in its turn, by concentrating valuable components in small gaseous volumes, makes it possible to utilize almost fully the dust and sulfur dioxide from the basic smelting units, and in a mixture of concentrated gases additionally use more of the weaker gases from other processes.

The solution to the problem of effective dust filtration is guaranteed by using the multi-stage purification of gases employed in sulfuric acid production, and if an approach is chosen of discharging gases without use of a smokestack--transition to dust filtration in hose filters.

The possibility of guaranteeing sanitary requirements is attainable in our country only if a dust-catching filter with spray refining is utilized in the capacity of a finishing apparatus and is rigged with a special double weave material. At present these filters at JSC Riaztsvetmet and a series of other enterprises in Russia and the CIS are securing the reduction of residual lead dust in discharged gases within the MPC levels for lead (it should be noted that in Russia the amount of maximum permissible concentration of lead in the atmosphere of 300 ng/m^3 is approximately half that of the majority of developed countries). Proceeding from the attained level of residual dust, which corresponds to the world level and which is defined by what contemporary technology permits, the conclusion follows that in order to cut atmospheric discharges by industrial enterprises, what remains in general terms is the introduction of new, progressive technologies that guarantee minimal volumes of discharged gases.

The environmental regeneration of the ***car battery industry*** in Russia is unthinkable without a technical re-equipping of the entire technological cycle of production with the application of the latest achievements in

technology and in the construction of equipment, including that of purification of the manufacturing discharges in the working areas.

For the reduction of discharges of lead and its alloys into the air and water, it is necessary to conduct a technical re-equipping of car battery factories with a change in technology and the use of new equipment enabling a streamlined purification of discharges into the air and the absence of drainage (reverse water supply). For that purpose it is necessary to purchase imported equipment (such equipment is not produced domestically) at a total of approximately $100 million.

In order to reduce lead contamination it is expedient to employ in automobiles capacity energy stores (the so-called "condensator starter") together with a car battery of small capacity. It would also be effective to introduce the latest achievements in the area of car batteries using an electrochemical nickel-zinc system.

At the present time in Russia specific work is being conducted in these spheres. In the cities of Kursk and Svirsk work is being done on the introduction of technical equipment purchased by contract with the firm Exide (USA) and other foreign companies. The Kursk car battery factory purchased from the company Varta (Germany) equipment for the smelting of car battery wastes and defective products. The Tiumen car battery factory purchased in Austria a production line for separators and created its own production of basic technological equipment (mills, dryers, etc.). The Saratov factory Electroistochnik purchased in Italy equipment for the casting of current taps, the production of powders and fillers. The Podolsk car battery factory purchased filler lines for the production of power of the type "Barton", etc.

The requirements of environmental safety with minimal capital investment and energy loss are met by the no-discharge technology of processing car battery wastes using hydrometallurgical, electrochemical, and low-temperature (600-700C) metallurgical processes.

The main task in improving the environmental characteristics of automotive gasolines is the complete refusal to employ lead-containing antiknock agents. Giving up ethylene introduces other problems related to the development of technological processes for the processing of crude oil and the goal of increasing octane ratings of gasoline, both of which require significant capitalization in the oil refining industry and time to modernize it. According to foreign economists, the decision to renounce the use of ethylene liquids in gasolines in Europe will require capital investments on the order of $26.7/ton of gasoline, but despite that the share of unleaded gasolines in western Europe continues to rise.

The transition to production of unleaded gasolines stipulates the reconstruction and introduction of new catalytic converting, catalytic crackings, hydrocracking, isomerization, alkalization, and the use of oxygenated, octane-increasing agents.

For the period 1996-2000 the subprogram "Reconstruction and Modernization of Enterprises Within the Oil Refining Industry" of the federal targeted program "Fuel and Energy" provides for the introduction of new capacities:

- catalytic cracking: 7 new units and the reconstruction of those in operation at 3 oil refinery plants with an overall capacity of 13.2 million tons;
- hydrocracking: 8 units and reconstruction of 1 in operation--11.1 million tons;
- coking: 3 new units and reconstruction of 4 in operation--3 million tons;
- catalytic converting: 11 units with a capacity of 9.3 million tons;
- alkalization and isomerization: 7 units--2.1 million tons;
- hydropurification of fuels: 8 units--12.5 million tons.

Alternative antiknocking agents include those based on manganese and iron, which do not have negative environmental effects since the background content of these elements is 2-3 times higher than that of lead. Research is being conducted in this country on the possibility of using CTM (cyclopentadienaltricarbonil manganese), appearing in its optimal concentration (0.5 g/l).

Use of agents based on ferrocenes is promising. Agents of this type combine well with catalytic after-burners and are used in the production of gasolines A-76 and AI-91 at the Anchinsk and Angara oil refinery plants.

An effective antiknocking agent of aviation gasolines is the low-toxic N-methylanylin. Approval for its use in antiknocking agents was obtained by Achinsk, Angara, Volgograd, Iaroslav, and several other plants.

Among the oxygenates, the most prevalent is methyl-tributyl ether (MTBE), the use of which decreases the creation and emission of toxic substances. A number of factories process pheterol. Up to 1 million tons/year of MTBE may be produced, with a demand for 3 million tons.

Alongside the absence of discharges of lead, another important advantage of using unleaded gasolines is the possibility of installing in automobiles catalytic converters of waste gases to reduce the content of unburnt

hydrocarbons, carbon monoxide, nitric oxides, and as a result decrease 70-90% of harmful discharges from automotive transport. At the moment, such after-burners are used widely in many countries and are extremely effective for reducing the level of air pollution from automobiles. However, the normal use of these systems is possible only on unleaded gasolines, since even one refueling with leaded gasolines causes the catalytic converter to be disabled.

It should be considered that according to conditions in 1995 the proposed yearly environmental loss from atmospheric pollution by discharges from autotransport as a whole for Russia equals US$2.7 billion. The complete renunciation of leaded gasolines would make it possible to cut that loss by US$1.44 billion. Here the widespread use of catalytic converters of waste gases from engines becomes a real possibility. A gradual equipping of all automobiles in Russia with converters would make it possible to reduce the yearly environmental loss from discharges of nitric oxides, hydrocarbons, and carbon monoxide by another US$0.8 billion.

In the *production of decorative* ***paints*** it is possible to stop using *lead pigments* entirely, replacing them with ferrates, titanates, and aluminates.

In Russia, work is being actively carried out to introduce steel shot in hunting cartridges in order to avoid environmental contamination by the **hunting industry** and amateur hunters. For this it is necessary to provide for the protection of the gun barrel from the steel shot and work out new types of cartridge cases and gun powder to accommodate the larger-volume steel shells.

In the area of processing **industrial and household wastes** for the reduction of environmental contamination and to solve the problem of the circulation of free lead it is necessary to first of all to regulate the system of disposal and processing of secondary raw lead (most of all worn-out car batteries) by creating regional organizations for the purpose. Here it is important to secure the monitoring of environmental contamination in regions of concentrated transport and industrial use of lead-containing equipment.

It is expedient to develop standards, an inventory, and a bookkeeping system for the handing over of secondary raw lead that comes from lead-containing equipment and car batteries no longer in operation.

A technical-economic analysis of the creation of new production outputs at full cycle at new and reconstructed (reprofiled) enterprises indicated the unquestionable advantages of the latter, since the presence of the buildings, equipment, transport links, and purification units in many cases may lower capital outlays by 3-5 times. Technical-economic calculations of the reconstruction of a series of Russian enterprises to process secondary lead shows that, depending on the size of production (15-30 thousand tons of commodity lead production), investment amounts equal US$9-15 million with a payback of 1.7 to 3.0 years. However, if a complex is created, including the collection, processing of secondary lead, and the manufacture of commodity production using lead and its alloys (car batteries, cables), then even with the investment in reconstruction, for example, in car battery production with the refitting of batteries produced so that they are of competitive quality, payback is not longer than 1.0-1.5 years. It should be kept in mind that the cost of lead in goods is 2-3 times higher than commodity lead and its alloys.

Proceeding from the above, a solution to the problem of preventing environmental contamination on the territory of Russia, while simultaneously guaranteeing lead production in the national economy, is a task of governmental importance and, independent of the sources of financing, the implemented measures should be kept under the control of the Government of the Russian Federation.

The cutting of discharges of lead into the atmosphere from **automotive transport** may be guaranteed by implementing a series of measures in the following areas:

An *increase in the fuel efficiency* (energy efficiency) of newly produced autotransport. According to available estimates, the structural characteristics of domestic vehicles are behind their higher (by 20-30%) fuel consumptions in comparison with analogous foreign makes. At the present time, a project of rules governing the requirements for vehicle fuel efficiency are being discussed in the working organs of the Committee for Internal Transport (CIT) of the European Economic Commission of the UN. Adoption by the Russian Federation of these rules and their implementation in a national system of vehicle certification would make it possible to announce corresponding requirements for fuel efficiency for domestic producers of autotransport. It is to be expected that domestically produced autotransport technology will correspond to international standard requirements in the field of fuel efficiency by 2003-2005. According to expert analyses, that would make it possible, by 2005, to lower the proportionate fuel consumption of vehicles (with gasoline engines) on average by 18-20%.

Change in the construction of automobile engines in order to replace leaded gasolines with alternative types of fuel (gas, alcohol fuels, biogas, hydrogen, etc.).

Broadening of the use in automotive internal combustion engines of compressed natural gas and liquefied oil gas. The transition, for example, of 10% of automobiles in Russia (cars, trucks, and buses) to gaseous fuels (cheaper than gasoline) would cut down on the use of leaded gasoline and lower lead discharges into the atmosphere by 25%.

In addition to the indication measures to reduce the use of lead gasolines, the following measures are also conducive:

- the production and wide use of trucks of varying payload capacities and buses, all with diesel engines (for example, an increase in the number of diesel trucks of up to 50% provides for a 22% decrease in the amount of lead being introduced into the environment by trucks);
- guarantee that during the transition stage supplies of unleaded gasolines will be available in the most environmentally vulnerable and densely populated areas;
- guarantee of the quality of the fuel that is being sold;
- improvement of organization and regulation of traffic, making it possible to lower the consumption of fuel by vehicles while in use on roads by 10-15% by limiting maximum speeds, equalizing speeds of moving traffic, increasing the evenness of movement, and decreasing delays at intersections;
- improvements in traffic control, making it possible to meet present demand for transport without increasing the number of automobiles in use;
- improvements in monitoring the technical condition of vehicles in use, which serves to reduce fuel usage on the average of 5-7%;
- transport calculations as part of urban development policy; development of a system of public passenger transport (decrease in per capita transport consumption, the creation of compact development zones with a developed trade and service infrastructure with good access to central parts of the city and industrial zones using public passenger transport, preferably electric);
- development of telecommunications technology, causing a reduction in travel;
- improvement in elements of government policy in the area of transport management (mechanisms for pricing, tariff, and taxation policy that stimulate the production and use of more economical transportation technologies, create equal conditions for competition between various types of transport, stimulation the redistribution of part of the transport volume to more environmentally "safe" types of transport, etc.).

4.2. Rehabilitation of Land

Despite the existence of significant territories that are contaminated with lead, work on their rehabilitation in Russia is currently conducted in very limited amounts.

Depending upon the degree of contamination of territories, it is possible to test various approaches.

For high and very high degrees of contamination, *physical methods* may be applied (removal and burial of contaminated layers of soil, glassing, dilution), as well as creating artificial geochemical barriers around contaminated plots of land to prevent the migration of pollutants to contiguous environments.

For lower degrees of lead contamination, various *chemical* (liming acidic soils, addition of mineral or organic fertilizers either taken separately or together, the use of zeolites and other absorbent materials to lower the mobility of lead in soil) and *biological* methods (harvesting of plants which weakly react to the excess of lead in the soil and do not accumulate it in quantities that are toxic for animals or humans; extraction of lead from soil using micro-organisms; cultivation of plants that are able to accumulate lead in large quantities--phytomeliorratives--with their subsequent removal from the territory, processing, or burial) or their combination may be used.

4.3. Improvement of Methods for Monitoring and Inspection of the Environment and Human Health

Reliable information about lead and lead compound contamination plays a huge role in understanding the basic sources of contamination and the identification of effective measures to lower lead contamination in the environment and decreasing its influence on human health.

In order to obtain trustworthy information the following tasks must be addressed: choice of research objects: air, soil, water, plantlife, human blood, etc.; determination of the basic sources of lead contamination; choice of

a plan, sampling area, and time intervals for the sampling; development of sampling methods and preparation; development of methods for analysis of the research object; development of a quality control system and method for ensuring the reliability of measurements; processing of information received and formulation of conclusions; conducting work in order to improve information supplies and lowering lead contamination. The carrying out of these tasks requires a systematic approach and the development of a complex of mutually connected programs, regulatory documents, methodologies, etc.

In terms of *research objects*, air, soil, water, and foodstuffs are usually chosen The systematic investigation of the juvenile population using analyses of lead content in the blood is practically never carried out.

The basic sources of lead contamination that have been established at the present time are sufficiently reliable. The greatest gaps in determining lead contamination of air and water are the absence of well-founded plans and sampling areas, as well as the frequencies at which this work is conducted. The available quantity of measurements are few and cannot reliably characterize the degree of actual contamination. It is here where mistakes accumulate which distort information concerning the diagnosis of lead contamination in the environment.

More favorable is the situation with regard to analytical methods of monitoring prepared samples. Standard methods of atomic absorption, spectrometry, X-ray fluorescence, and many others are used for this purpose. It should be noted that, in accord with WHO documents and those of other international organizations for the analysis of samples for lead content, the atomic absorption spectrophotometry method has been considered reliable.

It is necessary to regulate the systematic monitoring of the pollution of environmental sites, drinking water, and foodstuffs for ethyl and methyl derivatives of lead, the toxicity of which is significantly higher than that of simple lead salts.

The regulatory documents on methods of sample selection and preparation are clearly insufficient and, in those documents available, norms of accuracy are absent.

Also absent is a system for *quality control of measurements* and a necessary range of standards; feed-back on the improvement of the monitoring system and reduction of contamination is insufficient.

To the extent that a unified system which guarantees the receipt of thorough information in the country still does not exist, selective data and various types of calculations are used. These data cannot be viewed as sufficiently representative, but rather considered approximate. The amount of lead contamination in Russia is not known to a sufficient degree.

The monitoring of air conditions is carried out by the Russian Hydrometeorological Center, as well as by the laboratories of industrial enterprises. Since data from different laboratories even on instruments of the same type can differ from one another, in international practice quality control/quality assurance programs are employed to improve the quality of tests and comparability of data. From the end of the 1980s accreditation for environmental monitoring in Russia and elsewhere was begun for analytical laboratories of various departments.

Programs of interlaboratory quality control for measurements should be a priority task during the organization of a government system of environmental monitoring, since it would make it possible to guarantee reliability and compatibility of data.

An international methodology for evaluating the results of environmental contamination is the evaluation of the risk of environmental influence on humans. This approach suggests the modeling of environmental effects on humans using information on the concentrations of contamination of substances in various components of the environment. It is necessary to use this methodology for evaluating the risk of lead contamination of the environment in Russia with care because of the insufficiency of data on contamination of various environments and foodstuffs. Nonetheless, even very inexact estimations of risk performed using insufficient information makes it possible to determine the top priority problems requiring further improvement of methods of measurement, collection, and processing of data which have a regulatory basis. For the full use of available models, additional research and measurements must be carried out of the problems considered within the framework of the/a special program.

4.4. Medicinal-Prophylactic Measures

Medico-biological monitoring is one of the most vital links in the system of preventing effects of lead on the organism (see Section 3.2). The conducting of periodic medical examinations on individuals who work in contact with lead, makes it possible to detect the early signs of lead influence on the organisms of workers in time. Important tools of medico-biological monitoring are *preliminary examinations* before entering employment and *periodical medical check-ups of workers.*

It is necessary to introduce a two-tiered system of medico-biological monitoring, that includes determination of lead presence in hair (for the assessment of environmental danger in different areas) and in the blood (for high-risk groups). If necessary, the accumulation of lead in the human organism should be determined by performing tests for lead in teeth and bone tissue.

An important link in the system of medicinal-prophylactic measures is also *professional selection,* since individuals with a burdensome neurological case history or carriers of hematological abnormalities (porphyria, hemoglobinopathy, etc.) cannot work in contact with lead.

In preventing unfavorable effects of lead on workers' health, a leading role is played by the *use of lead-extraction preparations*:

- complex-forming compounds, which bind the metal and lead it out of the organism: D-penicillamine (also called: kuprenyl, kuprenym, etc.), chelates $CaNa_2EDTA$ and $CaNa_3DTPA$ (the question of their use as a prophylactic agent is up for discussion since it can be used only under the care of a doctor);
- pectins, which are part of many vegetables and fruits, are natural complex formers (they reduce the absorption of lead in the digestive tract, prevent its secondary reabsorption in the blood, and strengthen the process of leading the metal out of the organism); these are especially effective in those professions where workers are exposed to a longer-term (more than 5 years) influence of the metal in low concentrations;
- alginates, which are obtained from brown seaweed, able to draw out radionuclides and heavy metals;
- a steady does of vitamins B_1 and B_6 (the first is prescribed to improve metabolistic and mediator processes in the nervous system and the second is needed for the normalization of porphyrin exchange, which suffers first as a result of the effects of lead).

Also included within the complex of prophylactic measures to prevent the negative effects of lead on the health is physiotherapeutic methods (hydrotherapy, various forms of massage), sanatorium-health resort cures, especially at those resorts with hydrogen sulfide springs.

The principle of binding metals in the organs, stimulating their expulsion, enriching the blood with sulfydral groups, and normalizing the functions of the digestive system correspond to the medicinal prophylactic diet of workers in contact with lead during production: medicinal-prophylactic ration No. 3 is used, which has a total calorie content of 1466 calories and includes 62 g of proteins, 52 g of fat, 198 g of carbohydrates, and no less than 150 mg of ascorbic acid in the form of vegetables and fruits rich in vitamin C and which do not harm digestive processes. The dosage of medicinal-prophylactic food must precede the start of working in contact with lead, independent of the shift or time of the start of work. The ration, as with the home diet of the workers, should be rich in foods containing a large enough quantity of iron and calcium: beef, fermented dairy products, cheeses, beans, buckwheat, etc.

In order to draw lead out of the organisms of children, a complex biologically active food additive, developed by the Institute of Toxicology (St. Petersburg), is used, which contains apple pectin and nitrous alginate. An example of the successful reduction of lead in children's organisms using preparations containing vitamins, micro-elements, and sorbents has been achieved in the city Karabash (Cheliabinsk Oblast).

4.5. Improvement of the Legal and Regulatory Base and Economic Mechanism

For the purposes of *legislative guarantee* of the prevention and reduction of lead contamination of the environment the following is necessary:

- accelerate the passage of federal laws of the Russian Federation "On the preservation of air quality," "On protecting the population from the negative influence of oil products," "On production and consumption wastes," "On vegetation," "On the preservation of soils";
- develop and approve the federal laws "On dangerous substances," "On foodstuffs," "On the rehabilitation of lands contaminated by heavy metals," "On the evaluation of influences on the environment," "On motor fuels--liquidated and compressed natural gases," "On the sanitary purification of territories," "On packaging and labeling," and many others.

During the preparation of the indicated draft laws it is necessary to stipulate corresponding articles on the limitation on the use of lead, on the guarantee of measures to preserve human health, and on the preservation of the environment from lead contamination.

The development and improvement of a system of regulatory documents is necessary, which would regulate the influence of lead on the environment and human health: environmental and sanitary norms in the area of environmental preservation and rational use of natural resources (air, water, soil, layers of the earth, flora, and fauna); norms on the content of toxic substances in foodstuffs, raw food and manufacturing materials, wastes and on the influence of the branches of the economy on the natural complexes of human health, the spatial combination of various forms of natural resources use (pressure on the landscape, recreation, etc.); the organizational-methodological security of the protection of the environment and human health.

It is important to develop a *mechanism of economic stimulation*: use of taxation, customs duties, fees for licensing, excise duties on environmentally harmful products.

It is necessary to develop and apply at a national level proposals for the use of differentiated rates for the excise tax on fuel and lubricant materials in order to establish lower prices for the production of unleaded gasolines (by 10-20%) than leaded ones; differentiated rates of customs duties and taxes on the import of automobiles depending on whether they are equipped with catalytic converters; purchase and sale rights on discharges (disposals, wastes) of lead and lead compounds into the environment and the production of lead-containing products; the accelerated amortization of copper-smelting factories, metallurgical, machine-tool, and chemical enterprises which have ties to lead pollution of the environment.

Special attention needs to be given to consideration of factors of lead contamination of the environment during the course of auctions (trade) of government stock sales of privatized enterprises or their transfer to reliable management, as well as the introduction of organizational-economic methods of natural resources use (limiting, quoting, licensing, etc.).

On the other hand, it is necessary to provide for privileges to those enterprises that effectively implement means to preserve the environment, such as preferential loans.

During *product certification* it is necessary to take into consideration the observation of requirements regulating lead content.

In order to solve the problem of preventing lead contamination, economic mechanisms may be used with success at the local level as well. In the development of the Complex Environmental Program of Moscow, by resolution No. 341 of April 16, 1996, the Government of Moscow worked out a series of additional measures to lower the hazardous effect of autotransport on the quality of air in the city. A package of legislation to regulate the granting of tax concessions is proposed to be developed by 1998 for:

- physical and legal entities that make use of gaseous fuel, converters, filters, and other antitoxic devices while using means of transport;
- manufacturers of low-toxic automobiles and antitoxic devices;
- organizations that install into automobiles devices that increase their environmental safety;
- enterprises for the production and implementation in the city of motor fuels with improved environmental indices and for the reconstruction of automotive service businesses in order to increase their environmental safety.

It is proposed to:

- allow the assignment of budgetary means to the reconstruction and social needs of the bus fleets, which run buses on gaseous fuel, if these municipal means are freed up as a result of a decrease in the purchase of diesel fuel and gasoline;
- introduce economic sanctions for owners of the means of autotransport who do not meet toxic norms and other environmental norms and measures;
- establish a procedure for the stays of out-of-town and foreign transport;
- develop regional norms and methods of determining discharges of toxic substances;
- introduce environmental audits of transport;
- perfect a system of payments for the contamination of the environment by the automotive complex.

4.6. Scientific Research

An analysis of the available materials on the degree of environmental contamination by lead and lead compounds and the results of that contamination testifies to the incompleteness of our knowledge in the area under discussion. For the scientific-technical provision of the problems under review, it is necessary to:

- activate fundamental and applied scientific research within the framework of the federal targeted programs approved by the Government of the Russian Federation;

- broaden the volume and subject matter of research being carried out within the limits of competence of the Russian Academy of Sciences, the Russian Academy of Medical Sciences, the Ministry of Health of Russia, Ministry of Natural Resources of Russia, the State Committee for Environmental Protection of Russia, the Ministry of Industry of Russia, the Ministry of Fuel and Energy of Russia, the Ministry of Agriculture of Russia, the Ministry of Transport of Russia, the Russian Hydrometeorological Center, and other interested ministries, departments, and institutions in Russia;
- to develop a special scientific-technical program on the problem of lead contamination of the environment and its effect on human health;
- form special scientific-technical programs in the regions where lead production is located.

The scientific-technical work within the framework of these objectives should provide for:

- the development of new technologies which replace the traditional production of lead-containing products (leaded gasoline, lead paints and pigments, lead shot, cables, etc.);
- the development of technologies that are environmentally safe, conserve resources, produce minimal wastes, and are environmentally friendly, which would make possible the prevention or reduction of lead contamination in the environment;
- the development of scientifically based environmental norms;
- development of legislative, regulatory, and economic methods for regulating the reduction of lead contamination of the environment;
- the development of methods of analysis of the content of lead, including its organic derivatives, in various bodies of the biosphere and biosubstrata;
- complex research into the behavior of technogenic compounds of lead in the biosphere, including the development of methods of limiting the introduction and accumulation of lead in soils and agricultural crops;
- research of the influence of lead on living organisms in situations where the environment is polluted with other heavy metals and organic compounds;
- development of methods to prevent the influence of lead on the human organism;
- research into the long-term consequences of lead accumulation in the human organism, including the influence on the development of osteoporosis of the liver, of the postmenopause period, of the destruction of reproductive functions, and other changes;
- conduct of scientific research within the framework of the Convention on Long-Range Cross-Border Air Pollution, in particular on the development of methodologies and calculations on critical loads of lead;
- scientific guarantee of the obligations of Russia within the framework of the Basel Convention on the Control of Cross-Border Movement of Hazardous Wastes and Their Disposal, as well as other international conventions and agreements;
- adaptation of scientific-technical experience of other countries on the prevention of risk of environmental lead contamination for the conditions of Russia;
- development of methods of sanitary-environmental public education and accompanying information.

4.7. Environmental Education and Sanitary Instruction

An important role in solving the problem of environmental lead contamination is played by environmental education and the upbringing of the population. It is also necessary to inform the populace about those existing alternative consumer goods that do not contain lead and about the results of programs and measures to lower environmental lead contamination and its risk to human health.

Present-day environmental education and instruction of various groups of the population provides for continuous environmental education at both the federal and regional levels, including within the framework of the system of "Open Environmental Education."

Within the framework of preschool and school-age environmental education, in intermediate special and higher educational institutions it is necessary to include into the programs and methodological recommendations sections devoted to the problem of environmental contamination by lead.

The system of improving workers' qualifications should enable those instructed to receive fundamental natural-scientific preparation independent of the base education.

Instructive programs for the population, in those cases where people are organized within a work collective and have contact with lead as part of their work, make it possible for the workers to obtain a necessary amount of knowledge, the use of which will lower risks to health in practice. As a rule, this is a specific and fairly narrow volume of information that passes through the system of labor protection and technical safety of a specific enterprise.

For the broad mass of the population, there is practically no streamlined system of transmitting information about the problem of environmental lead contamination and its dangers to human health. The earlier existing Houses of Sanitary Instruction did specific work with people through teaching materials, which, of course, had a more general character than an instructive one. In recent years the activities of these institutions decreased significantly, but beginning in 1996 the Ministry of Health of Russia took up the task of trying to regenerate sanitary instruction work through the newly recreated centers of preventative medicine under the leadership of the Federal Center for Preventative Medicine.

Promising among these trends is the use of contemporary means of telecommunications: the international network Internet, the national system TV-ECOINFORM, and others. In the scheme of the organization of a system to inform the public about the threat of environmental lead contamination, it is necessary to provide for the preparation of informational materials (booklets, books, films, etc.) on the hazards of lead to human health and measures of personal protection and other aspects of the problem.

4.8. Other Measures

Considering that canned foodstuffs are distinguished by an increase content of lead (and that foodstuffs in Russia are a main way for lead to enter the human organism), it is necessary to develop a branch program on the transition to more contemporary technologies of production of canned foodstuffs, which provides for, in particular, the removal from use of those tin cans that contain lead soldering.

For a broader application of recommendations for the reduction of the risk of lead's influence on human health, it is important to put together a federal list of those territories that are contaminated by lead, which are more hazardous to the health of the population, as well as a register of stationary sources of lead contamination of the environment.

The Government of the Russian Federation must create the conditions for the implementation of mechanisms of public participation in the process of decision making about the preservation of the environment and the sustainable development of the country. NGOs could more actively participate in the formulation of national policies for the prevention of lead pollution of the environment, implement a monitoring function in the process of carrying out environmental protection programs, and exchange corresponding information with the public organizations of other countries. Public organizations could also fulfill the function of educating the public about problems associated with the dangers of lead and carry out independent analyses on lead contamination of the environment.

5. RECOMMENDATIONS

An analysis of the sources of lead contamination, the degree of environmental contamination by lead, the effect of that contamination on human health in the country, and the possible means for eliminating its negative consequences enables us to set forth the following system of measures to solve the problem under discussion.

On the **federal level**:

1. Take the necessary measures to carry out:
   - the subprogram "Reconstruction and modernization of petroleum processing enterprises" of the federal targeted program "Fuel and Energy" in the parts that provide for an increase of the percent share of unleaded gasolines in the total production of gasolines (Ministry of Fuel and Energy, Ministry of Economics, Ministry of Finance of Russia);
   - the federal targeted program "Technical re-equipping and development of metallurgy in Russia (1993-2000)," where measures are implemented to prevent and reduce lead contamination of the environment (Ministry of Industry, Ministry of Economics, Ministry of Finance of Russia);
   - the federal targeted program "Wastes" (State Committee for Environmental Preservation, State Committee for Science and Technology, Ministry of Economics, Ministry of Finance of Russia).

2. Develop in 1997 a federal targeted program "Protection of the Environment of the Country and Public Health from Lead Contamination for 1998-2005" (State Committee for Environmental Protection, State Committee of Science and Technology, Ministry of Economics, Ministry of Industry, Ministry of Fuel and Energy, Russian

Hydrometeorological Service, and other interested ministries and departments of Russia on the basis of the tenets of part 4 of this *White Paper*).

3. Implement fundamental and applied scientific research on the problems of lead within the framework of the federal targeted programs approved by the Government of the Russian Federation and broaden the volume and subject matter of research being carried out within the areas of their competence (State Committee for Environmental Protection, State Committee for Science and Technology, Russian Academy of Sciences, Russian Academy of Medical Sciences, Ministry of Health, Ministry of Natural Resources, Ministry of Industry, Ministry of Fuel and Energy, Ministry of Agriculture, Ministry of Transportation, and Russian Hydrometeorological Center).

4. Attract domestic and foreign investment for the modernization and construction of new technological plants for the production of high-octane gasoline components and the reconstruction of the corresponding metallurgical, chemical, and machine-building enterprises (Ministry of Economics, Ministry of Fuel and Energy, Ministry of Industry, Ministry of Foreign Economic Relations of Russia).

5. Accelerate the passage of draft laws of the Russian Federation "On the protection of air quality," "On the protection of the population from the negative effects of oil products," "On production and consumption wastes," "On the vegetable kingdom," and "On the protection of soils" (Federal Assembly of the Russian Federation).

6. Prepare draft Federal Laws of the Russian Federation "On hazardous substances," "On food products," "On the rehabilitation of land contaminated by heavy metals," "On the evaluation of influences on the environment," "On motor fuels--liquefied and compressed natural gas," "On the sanitary cleaning of territories," and "On packaging and labeling" (interested ministries and departments of Russia).

7. Prepare proposals on measures for legislative and administrative responsibility for the sale of leaded gasolines in the regions where its use is prohibited (Ministry of Justice, jointly with the Ministry of Fuel and Energy and the Ministry of Transport of Russia).

8. Provide for the organization of a system of complex environmental monitoring for the presence of lead in various parts of the environment, and especially in cities where there are principle sources of lead discharges (State Committee for Environmental Protection of Russia, Ministry of Natural Resources of Russia, Russian Hydrometeorological Center, State Committee for Land Resources, Russian Forest Service, and other interested ministries and departments of Russia, jointly with the Russian Academy of Sciences and organs of executive power of the member states of the Russian Federation).

9. Work out a system of measures for the utilization of secondary lead raw products, which provides for, in particular, the orderly collection and processing of worn-out car batteries (Ministry of Industry, Ministry of Transportation, Ministry of Defense Industries, Ministry of Natural Resources, State Committee for Environmental Protection, State Standards Committee of Russia).

10. Work out measures for the transition to more contemporary production technology for the preservation of food products, which makes provisions for, in particular, removal from use of tin cans with leaded soldering (Ministry of Agriculture, Ministry of Industry of Russia).

11. Secure the development and implementation of necessary measures for the replacement of lead shot with steel in hunting cartridges (Ministry of Industry of Russia).

12. Introduce a two-tiered system of medico-biological monitoring, including determination of lead presence in hair for the assessment of environmental danger in different areas and in blood for high-risk groups (Ministry of Health, Russian Academy of Medical Sciences, organs of executive power of the member states of the Russian Federation).

13. Organize the conducting of medicinal-prophylactic measures to lower the risk the influence of lead contamination on the condition of children's health, especially in cities with major sources of lead discharges into the environment (Ministry of Health of Russia and the organs of executive power of the member states of the Russian Federation).

14. Develop a federal list of territories contaminated with lead that are the most dangerous to human health, as well as a register of stationary sources of environmental lead contamination (State Committee for Environmental Protection, Russian Hydrometeorological Center, Ministry of Natural Resources, State Statistical Committee).

15. Develop proposals for the organization, on the basis of existing laboratories of methodological analytical centers, of a determination of lead in environmental bodies and biosubstrata (State Committee for Environmental Protection, Russian Hydrometeorological Center, Ministry of Health of Russia, and other interested ministries and departments).

16. Prepare proposals for the organization of a system of public information on the threat of environmental lead contamination, which provide for the preparation of informational publications on the danger of lead's effect on health, measures for individual prophylactic steps, as well as measures for the compulsory informing of the public about the presence of lead in products (Ministry of Health of Russia, State Committee for Environmental Protection).

On the **level of the member states of the Russian Federation** and at the local level, the expedient passage of legal and regulatory acts and programs for the regulation of discharges and disposal of lead into the environment, which provides for, in particular:

1. The administrative regulation of the production of leaded gasolines.
2. The creation of a network of specialized enterprises for the collection and processing of industrial and household leaded wastes.
3. The rehabilitation of territories contaminated with lead.
4. The conduct of a set of measures aimed at the prevention of the unfavorable influence of lead on the health of the population (for regions with high levels of lead contamination).
5. The development and implementation of economic stimulation measures.
6. Measures for the rational organization of traffic.
7. Strengthening of the monitoring of the technical condition of autotransport being used.
8. The improvement of the management of transport and the development of public passenger electric transport.
9. The implementation of a municipal development policy aimed at reducing public use of transport.

It is necessary for the administrations of member states of the Russian Federation in regions where essential sources of lead contamination are located, for the territorial nature protection organs, together with scientific institutes and other interested enterprises, to form special scientific-technical programs for the prevention of lead contamination of the environment.

On the **level of industrial enterprises**, which have a part in the contamination of the environment by lead, it is necessary to address the following issues:

1. Changes to the technology of the fusing of lead and its alloys, copper, zinc, and other metals (the universal use of electric kilns, non-flux fusion), the improvement of sanitary-technical devices.

2. The creation of a capacity for processing secondary raw lead.

3. The introduction of advanced technological processes and equipment for the production of high-octane, unleaded gasolines.

4. The refusal to use lead pigments in the production of decorative paints, replacement of them by ferrates, titanates, and aluminates. In this regard, a necessary measure is the organization of strict environmental monitoring (both governmental and industrial).

5. Conducting of technical re-equipment of car battery plants with an application, in particular, of equipment with a streamlined purification of discharges into the atmosphere and the absence of drainage (reverse water supply).

6. The securing of changes in the construction of automotive engines in order to substitute leaded gasoline with alternative forms of fuel (natural and liquefied oil gaseous, alcohol fuel, biogas, hydrogen, etc.) and electric energy.

7. The increase in fuel economy (energy efficiency) produced by domestic means of transport that have a higher (by 20-30%) fuel consumption in comparison with foreign analogs.

An important role in the solution of environmental lead contamination problems can be played by the public environmental movement. NGOs could more actively participate in the formation of a national policy for the prevention of lead pollution of the environment, fulfill a monitoring function in the process of carrying out environmental preservation programs, and exchange useful information with public organizations of other countries.

Public organizations could also fulfill the function of educating the public about problems associated with the dangers of lead and carry out independent analyses on lead contamination of the environment.

On the efficiency with which NGOs can fulfill these functions in the near future will depend much of the fate of the recommendations for preventing environmental lead contamination in Russia that have been discussed in this *White Paper*.

LIST OF ABBREVIATIONS

APC	Approximate Permissible Concentration
ASLI	Approximate Safe Level of Influence
CDC	Centers for Disease Control
CIS	Commonwealth of Independent States
CTM	cyclopentadienaltricarbonil manganese
GAI	State Auto Inspection
GOST	State Standard
GSO	Government Service of Observation of the State of the Environment
IOL	International Organization of Labor
IWG	International Working Group
JSC	Joint-Stock Company
MPC	Maximum Permissible Concentration
NGO	Non-Government Organization
PDD	Permissible Daily Dosage
PRA	Permissible Residual Amount
PSPTE	Production-Scientific Planning-Technological Enterprise
REFIA	Russian Ecological Federal Information Agency
RF	Russian Federation
SCBM	System of Complex Background Monitoring
SHW	Solid Household Waste
SSC	State Statistical Committee
UNCTAD	United Nations Conference on Trade and Development
USAID	United States Agency for International Development
WHO	World Health Organization