Article

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Soviet and Post-Soviet Environmental Management: Lessons from a Case Study on Lead Pollution

Through a case study on lead pollution in the former Soviet Union, the linkage of policy, environmental science, and environmental management is explored, and compared with the US experience. Soviet bans on leaded gasoline and lead-based paint appear to have been effective. Regional governments, in cooperation with the petroleum industry, are taking the initiative in phasing out leaded gasoline, to some extent in defiance of federal policy. Problems with management of lead-acid batteries have been worsened by the collapse of the political system. Lack of reliable environmental data impedes reliable environmental assessment. The types of environmental measurements reflect an emphasis on multipollutant environmental contamination, rather than on human exposure to single pollutants.

ENVIRONMENTALISM AND ANTI-SOVIET POLITICS

The environmental movement was central to the political transformation of the Soviet Union. As reported in *The Economist* in 1989, "The preservation of nature has become a national obsession.... Green feelings now run as deep, and are as politically challenging, as anywhere in the world.... The most influential informal organizations in the Soviet Union are the so-called popular fronts,... pressing for greater political, cultural and economic autonomy. Most began as green lobbies" (Nov. 4, pp. 23–26). Open criticism of Soviet environmental management was also a prominent feature of the Soviet government's "glasnost" program. The Chernobyl accident, which occurred only a few months after Gorbachev came to power, practically ensured that environmental issues would become a major focal point of glasnost (1). In the late 1980s, Fyodor Morgun, chairman of the Soviet State Committee for Environmental Protection, said, "For a whole era our party and professional propaganda and science have been intolerably passive as far as ecology is concerned. For many decades, the environment has been undergoing catastrophic pollution" (2).

Western observers have echoed these sweeping denouncements of the Soviet government's environmental management (3). For example, *US News and World Report* reported that "decades of recklessness and stupidity have left dozens of environmental horror stories" (10 Feb. 1992, pp. 46–47). In *Ecocide in the USSR*, Feshbach and Friendly write that "When historians finally conduct an autopsy of the Soviet Union and Soviet Communism, they may reach the verdict of death by ecocide.... No other great industrial civilization so systematically and so long poisoned its land, air, water, and people" (4).

There is ample evidence of serious environmental contamination in the former Soviet Union. Yet the sweeping environmental rhetoric also reflects the linkage between environmentalism and anti-Soviet politics. Here we explore the linkage of policy, environmental science, and environmental management in the former Soviet Union through a case study of lead pollution, which shows a more complex and multi-faceted situation than what is typically reported as the Soviet environmental legacy. Some aspects of lead pollution in the former Soviet Union are severe and require immediate attention. There is widespread mismanagement of used lead-acid batteries. Environmental data and measurements of lead are of very poor quality. However, there are other aspects in which lead pollution seems to be mild compared to the situation in some OECD countries. The Soviet Union implemented some effective environmental restrictions well before the United States did, including bans on use of leaded gasoline in some areas and on lead in paint.

The role of science in Soviet and post-Soviet environmental policy, and the roles of the federal government and regional governments in addressing environmental problems are all rather different from those in the US. In the former Soviet Union, there is more emphasis on holistic approaches to environmental management, and correspondingly less emphasis on reductionist science. The devolution of authority from the federal government to the provinces is also reflected in post-Soviet environmental policy, with regional governments taking the initiative in environmental policy.

We address some positive achievements of Soviet environmental policy, problems with Soviet and post-Soviet environmental analyses, environmental effects of the collapse of the state and the economy, and the strength of regional governmental environmental initiatives in Russia, beyond and to some extent in opposition to federal policy. We conclude with a discussion of the unexpected findings of this case study.

ACHIEVEMENTS OF SOVIET ENVIRONMENTAL POLICY

The Soviet Union prided itself on its high environmental standards; the Soviet constitution stated that "citizens of the USSR are obliged to protect nature and conserve its riches." It is now acknowledged that many of the Soviet Union's environmental standards were not enforced. Nevertheless, the Soviet Union took effective action to protect the population from lead exposure; it banned lead-based (white lead) paint and it banned the sale of leaded gasoline in some cities and regions.

While leaded gasoline was introduced in the 1920s in the United States, it was not until the 1940s that leaded gasoline was introduced in the Soviet Union (5). In the 1950s, the Soviet Union became the first country to restrict the sale of leaded gasoline; in 1956, its sale was banned in Moscow, Leningrad, Kiev, Baku, Odessa, and tourist areas in the Caucasus and Crimea, as well as in at least one of the "closed cities" of the nuclear weapons complex (6, 7). The motivation for the bans on leaded gasoline is not entirely clear, but factors may have included Soviet research on the effects of low-level lead exposure (8), or support from Stalin himself (5). In any event, the bans on leaded gasoline in some areas prevented what could have been significant population lead exposure. In the United States and other OECD countries, leaded gasoline has been identified as one of the largest sources of lead exposure (9, 10).

Lead-based paint is another potentially significant source of population lead exposure. Along with a number of other countries, in the 1920s the Soviet Union adopted the White Lead Convention, banning the manufacture and sale of lead-based (white lead) paint (11). In the United States, however, the National Paint, Oil and Varnish Association successfully opposed the ban, and lead-based paint was not banned in the United States until 1971 (12). Although the Soviet Union enforced the ban on white lead paints, it nevertheless continued to produce some paint containing smaller amounts of lead. In a study of sources of lead exposure in Moscow day-care centers, we found concentrations of lead in paint of up to about 2% (13). But by banning white-lead paint the Soviet Union largely avoided one of the most damaging and difficult types of environmental lead contamination.

The Soviet Union's action on lead-based paint and on leaded gasoline took the form of bans. Commoner has argued that the most successful US environmental measures have all been bans: the ban on DDT, the ban on lead in gasoline, the ban on aboveground nuclear tests, the elimination of mercury from chlorine production, the ban on phosphates in laundry detergents (14). Efforts to reduce pollution without a fundamental change in technology are inherently susceptible to evasion and therefore typically require disciplined enforcement in order to be effective. The effectiveness of bans in comparison with restrictions may be even more pronounced for the former Soviet Union than for the United States, because environmental regulations in the former Soviet Union in general were not enforced. In contrast, the bans on lead-based paint and leaded gasoline required the complete and irreversible shut-down or re-tooling of some industrial facilities. The refineries for Moscow, Leningrad, the Caucasus and Crimea produce only unleaded gasoline. No significant violations of these bans have been reported.

SOVIET AND POST-SOVIET ENVIRONMENTAL INFORMATION AND ASSESSMENT

The lack of credible environmental information has been widely acknowledged within the Soviet Union. The first Report on the State of the Environment in the USSR in 1988 stated that "official, open information on ecological conditions and human morbidity was virtually unavailable prior to 1987.... Undoubtedly such information is necessary for both the purpose of decision making and of eliminating embellishments of any kind..." (15). Eduard Shevardnadze, former Soviet Foreign Minister, wrote in 1989, "Why did we keep data on the environmental situation in this country a secret from the international community and from our own people for so long? Why didn't we release any information on major ecological catastrophes which happened in our territory?" (16).

Secrecy and restrictions covered all economic data during the Soviet period. The lead industry was not excluded from these restrictions, and in fact these restrictions continue today. For a brief period in 1995, the Russian Government permitted the publication of mineral industry data that had been secret during the Soviet period, but in November 1995, an edict was signed "On State Secrets" that reclassified as secret a great deal of information on the mineral sector in Russia, including information on the production of ferrous and nonferrous metals (17). Thus, it has been officially impossible to assess how much lead is produced and used, what it is used for, and where it goes. On the other hand, throughout this period, the International Lead and Zinc Study Group (ILZSG), a UN-based trade organization, and the US Bureau of Mines annually published Soviet and Russian lead production data, based on data reported by the Soviet government and reports from Soviet and Russian lead producers. Thus, Russian production data are simultaneously state secrets so far as Russian citizens are concerned, but readily available internationally.

Some problems with Soviet and post-Soviet environmental assessments stem not so much from secrecy as from a lack of effective quality control at environmental laboratories. In 1991, V. I. Danilov-Danilyan, the Russian Minister of Environment, wrote that "There are doubts about the reliability of some measurements in view of the poor quality of the instruments, lack of stations and information processing centers.... Environmental monitoring in the USSR undoubtedly requires major improvement in such areas as refinement of the network of observation stations, the supply of more advanced equipment of various kinds, better quality staff, substantial changes in working methods, and a qualitative breakthrough in the systematization and processing of data" (18).

We have found that some Russian analytical techniques provide results that differ, consistently as much as an order of magnitude, from those from certified US laboratories. In a 1995 study, we took soil samples from 6 Moscow day-care centers. We split the samples and sent them to both US and Russian environmental laboratories for analysis (13). The standard Russian method for soil lead analysis is atomic emission spectroscopy (spectral analysis) without digestion of the sample prior to measurement. We found that Russian laboratory results for soil-lead analysis were consistently a factor of 10 lower than US laboratory results for the same samples analyzed by atomic absorption spectroscopy with nitric acid digestion of samples prior to analysis. Consistent with this result, Russian environmental data on heavy metals in soils are typically significantly lower than levels reported at similar sites elsewhere in the world. For example, in lead-contaminated industrial sites elsewhere in the world, soil-lead levels of over 10 000 ppm are not uncommon (19). But in Russia, the highest reported levels of soil lead contamination are on the order of 2000 ppm, even at the most contaminated smelter and mining sites (20). Many Russian specialists understand the limitations of spectral analysis. But the lack of advanced equipment at many state environmental laboratories has precluded the adoption of better measurement techniques (Russian Ministry of the Environment, 22 May, 1995).

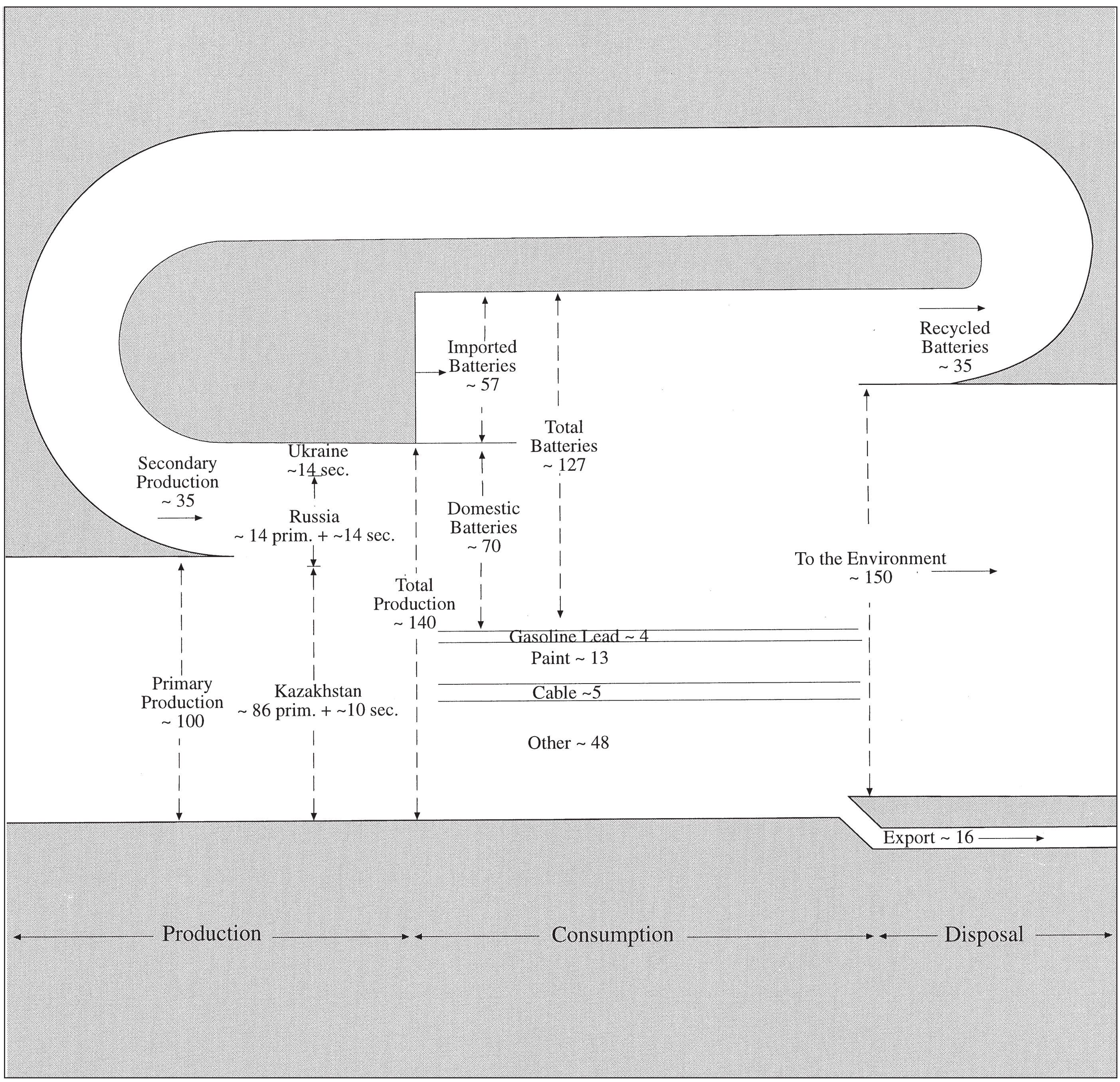
Problems with the measurement of trace pollutants in general and lead in particular are by no means unique to the former Soviet Union. Laboratory quality assurance and quality control remain central issues in the assessment of lead contamination everywhere. A 1993 study by the US National Research Council stressed the need for "strict attention to contamination control and other quality assurance and quality control procedures" (21). In many countries, government agencies maintain and make available standard samples for use in laboratory quality assurance procedures. International intercalibration exercises have been particularly useful in providing assurance of international consistency of measurements of human exposure. For example, in the early 1980s the United Nations Environment Program and the World Health Organization sponsored an international project for calibration of measures of human exposure to lead and to cadmium, and included the participation of researchers and laboratories from Belgium, India, Israel, Japan, Mexico, China, Peru, Sweden, United States, and Yugoslavia (22). Participation by laboratories of the former Soviet Union in international intercalibration programs will be essential to the development of reliable environmental data.

Beyond issues of measurement quality, there are differences between the types of environmental measurements made in the former Soviet Union and those made in OECD countries. For example, the standard international measure of human exposure to lead is blood-lead concentration. But in Russia, the standard measure of lead exposure in the general population is lead in hair (23), even though in the international literature, hair-lead analysis has been shown to be an unreliable indicator of lead exposure (24). For occupational exposure monitoring, basophil stippling in blood and EPP measurements in urine are used, both of which are reliable only for high levels of exposure. Measurements of lead in urine are sometimes reported in Russia, but lead concentrations in spot urine samples have also been shown to have a poor correlation with exposure or blood-lead concentrations (25). Highly exposed workers will have blood-lead measurements taken when admitted to occupational health clinics, but these data are not publicly available (N. S. Sorkina, M.D., Inst. Occup. Health, Moscow, 1998, pers. comm.). Thus, it has been difficult to assess the results of lead contamination in Russia because there are almost no reliable data on human lead exposure.

Recently, the US CDC analyzed the blood-lead levels of 579 children in the Russian city of Saratov. They reported an average blood-lead concentration of 7.7 μg dL^{-1}, with a range of 3.0 to 35.7 μg dL^{-1}; 25% of the children had blood-lead levels greater than 10 μg dL^{-1} (26). For comparison, average population blood-lead levels in the US were 2.9 μg dL^{-1} as of the early 1990s, and were about 17 μg dL^{-1} in the late 1970s when leaded gasoline was still widely used. Thus, the Saratov children's blood-lead levels are significantly lower than US blood-lead levels from the 1970s, but are significantly higher than current US blood-lead levels. In addition, a study of 29 Soviet males aged 17–53 reported a median blood-lead concentration of 4.6 μg dL^{-1} (27). If these results were typical, they would indicate that average blood-lead levels in the former Soviet Union are similar to those in western Europe (28). But more and better data are needed before a firm conclusion can be drawn.

In Russia, the emphasis is more on comprehensive approaches, and less on proving whether or not a particular pollutant is causing a particular effect. There is relatively little interest in detailed assessments for a single pollutant, but more interest in broader assessments of a number of pollutants together. As expressed in an overview entitled *Population Health and Environmental Chemical Pollution in Russia*, "scientific research aimed only at establishing the link between yet another pollutant and yet another illness, does not try to address the problem as a whole" (29). While in the US there is great emphasis on quantifying the actual human exposure to pollutants, in Russia we have found little emphasis on quantifying exposure, and more emphasis on identifying overall contamination of the environment. The lack

Figure 1. Production, consumption and recycling of lead in the former Soviet Union, 1995 (thousand tonnes). Data from Tables 1 and 2.



of emphasis in Russia on human exposure could help to explain why measurements of exposure, such as blood-lead concentrations, have not been extensively developed.

The nonreductionist approach, and the emphasis on contamination of the environment rather than on human exposure, extends to the measurements made, and to how they are made. In 1987, the USSR Ministry of Health defined a measure of the "state of the environment," called Total Coefficient of Pollution (TCP). TCP is a measure of the elevation of the concentration of metals in soil above background levels, calculated as follows:

$$TCP = \Sigma\ (C_i - C_0)\ /C_0$$

where C_i is the concentration of each metal in the soil (measured by spectral analysis), C_0 is the background soil concentration of each metal, and the sum is over 40 metals. The background soil concentrations are reported in the annual reports of the State Committee of Hydrometeorology (V.A. Surnin, State Committee of Hydrometeorology, pers. comm. 1999). The threshold TCP value is 16; increases in total illnesses have been associated with TCPs of 16 and higher. A TCP of 16–32 is considered "moderate"; 32–128 is considered "dangerous" and a TCP of over 128 is classified as "extremely dangerous" (30). TCP is an attempt to measure exposure to multiple pollutants. Yet this approach would not meet the needs of American environmental assessment criteria, because it fails to take into account the fact that some metals are much more toxic than others, that soil pollutant levels may not accurately reflect human exposure to pollutants in air, water, and other media, and that some pollutant levels can be elevated even if the overall TCP is low. However, it does address the Russian interest in assessing an overall level of contaminants in the environment. Ecological maps commonly published in the former Soviet Union are based on measurements of TCP.

The methodology and status of Soviet environmental measurements might be partially attributed to the Soviet and post-Soviet approach to environmental management. In the United States, environmental regulations almost always face strong opposition from the affected industries and their political allies, and much of this opposition is couched as criticism of the scientific basis for environmental claims. In the US, there is also an emphasis on monitoring to demonstrate compliance, because it is not assumed that industry will unfailingly comply with government decrees. As a result, US environmental measurements and environmental science are subject to very rigorous review; political controversies provide the support and justification for detailed assessments of environmental problems on a pollutant-by-pollutant basis.

This type of environmental politics, mediated by scientific arguments, did not exist in the Soviet Union, and does not exist now in the post-Soviet states. In its framework document, the Center for Russian Environmental Policy, an environmental NGO, states that "Scientific research ... has not traditionally been actively used to influence policy" (31).

COLLAPSE OF LEAD-ACID BATTERY RECYCLING

Overall, Soviet and Russian lead consumption has been similar to lead consumption patterns elsewhere in the world, with lead-acid batteries accounting for the the major part of consumption, and with the rest used in glass and pigments, solder, cable, gasoline, and other products, probably including ammunition and some construction applications (Fig. 1; Table 1).

Lead-acid batteries are readily recycled, and are by far the main feedstock for secondary lead smelters worldwide. The trade association for the international lead-acid battery industry—Battery Council International (BCI)—regularly issues press releases touting lead-acid battery recycling as an environmental success story. Citing US data, BCI states that "lead-acid batteries topped the list of the most highly recycled consumer products for the 10th consecutive year, with a recycling rate of 96.5 percent" (34). Based on the high recycling rate and on reductions in occupational exposures and emissions, Socolow and Thomas argued that lead-acid batteries could become one of the first examples of use of a hazardous material in an environmentally acceptable fashion (35). But the Soviet and post-Soviet lead-management system does not resemble US practice.

The Soviet Union had a planned system of collection and recycling of lead-containing wastes through VtorTsvetMet, the secondary nonferrous metals industry. Consumers, companies, and individuals were required to return their used batteries in order to purchase new ones. But even when batteries were recycled in the former Soviet Union, there may have been significant environmental and occupational health problems. Used batteries were transported long distances by train (typically from Russia to Kazakhstan). To avoid problems with leakage of battery acid during transit, battery acid was drained from the batteries before they were shipped for recycling, a practice called "dry recycling" (V. Kopach, chief metallurgist, Tumen Battery Plant, 1999, pers. comm.). Usually, the acid was simply poured onto the ground, which can result in significant contamination of soil and groundwater. Nevertheless, despite its shortcomings, lead battery recycling was well established in the Soviet Union and was essential for providing lead for manufacture of new batteries.

But with the political and economic collapse of the Soviet Union, both lead production and lead recycling have collapsed. Kazakhstan was the primary lead producer of the former Soviet Union, and that production plummeted in the 1990s (Fig. 2; Table 2). Almost all of the lead produced in Kazakhstan was and is shipped to Russia, primarily for production of lead-acid batteries (36). Thus, when lead production in Kazakhstan collapsed, Russian battery manufacturers lost much of their lead supply.

The battery recycling system broke down at the same time. As of the late 1990s, there is little recycling of lead-acid batteries in Russia. Because they were no longer required to do so, car owners no longer brought in their used batteries for recycling. For example, the manager of an ambulance fleet in the city of Chelyabinsk said that he used to take all his old batteries to VtorTsvetMet for recycling, but that since 1994 VtorTsvetMet requires that customers

Table 1. Lead Consumption in Russia (thousand tonnes of lead). Data from (32) unless otherwise noted.

Year	Batteries	Gasoline additives Produced (a)	Gasoline additives Used	Paint	Cable	Glass	Export (33)
1985	240 ± 10				4.5		
1986							
1987							14
1988							12
1989						> 1.3	32
1990							53
1991	127	5.2	~ 7				45
1992	132	4.3					70
1993	151	5.1					
1994	$81 + 65^i - 28^e$	4.1					
1995	$71 + 57^i - 16^e$	4.0	3.7	~ 13	~ 5		
1996	71	5.2					
1997			~ 2				

i - imports. e- exports. (a) V. Prozorov, Dzerzhinsk City Committee on Environmental Protection, pers. comm.

open the batteries, dump the acid, and bring only the lead plates for processing. Because this is both dangerous and difficult, the ambulance manager now simply throws the batteries in the dump. There is only one secondary lead smelter which accepts lead-acid batteries, in Vladikavkaz. (A battery plant in Tumen, eastern Siberia, melts lead from old batteries for reuse in new batteries.) As shown in Table 2, secondary lead production as of 1996 has plummeted to about 30 000 tonnes. As a result, battery production has plummeted, with much of the shortfall replaced by imports (Table 1).

In addition to showing that there are problems with Soviet and post-Soviet management of lead-acid batteries, this example indicates that the recycling of lead-acid batteries may be inherently vulnerable to political and economic disruptions. While the shortage of Russian-produced batteries has been amply overcome by battery imports, the re-establishment of systems to collect and recycle used batteries is likely to be difficult. Data on the environmental performance of the lead-acid battery industry in the former Soviet Union are unavailable, but this is an industry that is likely to have environmental and occupational health problems if oversight is weak.

REGIONAL INITIATIVES: THE PHASE-OUT OF LEADED GASOLINE IN RUSSIA

Despite the ban on leaded gasoline in some locations during the 1980s and early 1990s the Soviet Union as a whole was one of the world's largest users of lead in gasoline, using roughly 7000 t yr^{-1} (38). Russian regulations restrict lead concentrations in gasoline to 0.17 g L^{-1} for regular gasoline and 0.37 g L^{-1} for premium gasoline (GOST No. 2084-77) (38). Although this is not a particularly high lead concentration (many African countries have gasoline lead concentrations of 0.6 g L^{-1} or more), the relatively large amount of gasoline used in the Soviet Union has resulted in a high total use of lead in gasoline (28).

In the early 1990s, there seemed to be little incentive for the Soviet Union to phase out leaded gasoline. Historically, the Soviet Union has bought about half of its lead additives from the UK-based Octel, and has manufactured the rest in the city of Dzerzhinsk, which the Washington Post has called "the most polluted city on earth" (8 July, 1997). The lead additive plant is the only profitable enterprise in Dzerzhinsk. Shutting down the Dzerzhinsk lead additive plant would increase unemployment in a city already under severe economic stress, and thus local authorities are making every effort to keep the plant in operation (V. Prozorov, Dzerzhinsk City Environmental Committee, 1997, pers. comm.).

Moreover, the production of unleaded gasoline usually requires petroleum refinery upgrades for construction of modern alkylation and catalytic reforming units. Russian refineries are plagued by overcapacity, obsolescence, and huge financial problems (39). Although the western press has stressed the need to shut down antiquated refineries in order to restore health to the refinery sector overall, all of the main refineries remain in operation. There have been many plans for refinery upgrades in the 1990s, but almost all of them have fallen through.

Despite these problems, use of lead in gasoline in Russia has dropped by about a factor of 3 during the 1990s. As shown in Figure 3, between 1991 and 1994 unleaded gasoline production remained constant while total gasoline production decreased, and then from 1994 to 1997 total gasoline production remained approximately constant while unleaded gasoline production increased. In 1991, about 7000 tonnes of lead were used in gasoline in Russia, whereas in 1997, the total was down to about 2000 tonnes, less than a third of the 1991 amount (38).

How has Russia managed to make such progress in phasing out leaded gasoline, despite its economic problems and antiquated refinery sector? In the United States and some other OECD countries, the lead industry put up a fight against government policies to phase out leaded gasoline, claiming that making the transition would be far too expensive, and that the environmental benefits would be nominal. In a 25-year struggle, from 1970 to 1995, the US EPA gradually reduced the amount of lead allowed in gasoline, with the lead additive industry fighting each step of the way. US environmental NGOs, particularly the En-

Figure 2. Total lead production in the former Soviet Union, 1986–1997.

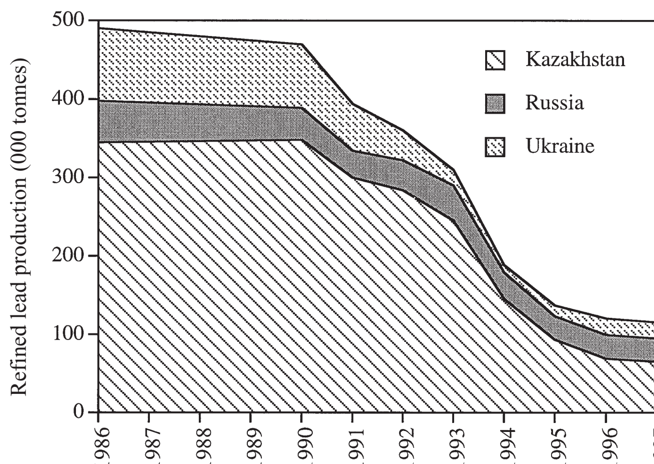


Table 2. Production of refined lead in the Former Soviet Union (thousand tonnes of lead). Data are from the International Lead and Zinc Study Group (ILZSG), the United States Geological Survey (USGS) (37) and the Russian Government (RG) (38).

Year	Kazakhstan				Russia					Ukraine		Total		
	ILZSG Total	USGS Prim.	Second.	Total	ILZSG Total	USGS Prim.	Second.	Total	RG Second	ILZSG Second.	USGS Second.	ILZSG	USGS	RG Total
1985													453	
1986	345				53					92		490		
1987														
1988														
1989														
1990	348				41					81		470		413
1991	300				34					60		394		359
1992	284	180	30	210	38	18	15	33		38	20	360	263	
1993	245	125	25	150	45	18	14	32		20	17	310	199	
1994	145	75	20	95	34	22	4	26		9	12	188	133	
1995	93	89	10	99	30	22	4	26	14	14	14	137	139	
1996	69	69	10	79	30	20	5	25		21	12	120	116	
1997	60				32					22		114		

Note: The data from the ILZSG are higher than both the USGS data and the Russian Government data, and probably reflect past Soviet overstatements of production.

vironmental Defense Fund and the Natural Resources Defense Council, played essential roles in pressing the US EPA to phase out leaded gasoline, despite pressure from the lead industries (40).

The Russian phase-out of leaded gasoline has not resembled the US phase-out. In Russia, recent governmental measures to phase-out leaded gasoline have come not from the federal government but from the regional governments. As of the late 1990s, the sale of leaded gasoline has been banned in the regions of Nizhny Novgorod, Bashkortostan, Tartarstan, and Khabarovsk, and in the cities of Perm, Volgograd, Ryazan, and Saratov (Fig. 4) (41) (V. Shelekov, Ministry of Fuel and Energy, 1995, pers. comm.) (42). As can be seen from Table 3, the refineries in all of these locations have significantly decreased their production of leaded gasoline between 1994 and the late 1990s. The regional governmental actions were apparently in cooperation with, and of direct benefit to, the regional refineries, providing a near monopoly to the regional refinery for production of unleaded gasoline. As can been seen from the map in Figure 4, the refineries in Kuibuishev, Novokuibishev, Sizran, and to some extent Orsk, all of which produce mostly leaded gasoline, are now virtually surrounded by regions which have banned or partially banned leaded gasoline, and which have their own refineries which now produce mostly or entirely unleaded gasoline.

The strong links between regional governments and local industry are openly acknowledged and are seen as critical to the economic and political stability of the regions. For example, Gennady Igumnov, Head of the Perm regional administration, said close links with Lukoil, the company that owns the refinery located in the Perm region, helped him take the region out of post-reform economic tumult. And reconstruction of the Perm refinery is one of the few investment projects in Russia's petroleum sector that has actually been completed in the 1990s. But at the same time, the regional government is reported to have lost some 1 trillion rubles (USD 200 million) in 1995 because of the soft taxation regime on Lukoil and its subsidiaries. The Perm regional authorities have also lobbied the federal government for tax breaks for Lukoil. "What's good for Lukoil is good for the Perm region," said Yevgeny Sapiro, Head of the Perm legislative assembly (*Moscow Times*, 10 Dec. 1995).

The competition between regions, and alliances of local industries with local governments, also affects distribution of crude oil to refineries. For example, it is reported that a deal has been made between oil-producing companies, the Russian central government, and the government of the Irkutsk region to supply oil to the Irkutsk regional refinery in Angarsk. As a result, other refineries are having trouble getting enough crude oil. The Angarsk refinery was threatened with a take-over by the federal government in December 1997 for nonpayment of debts (43). Angarsk's negotiated settlement may be linked to its current easy access to petroleum and its continued production of leaded gasoline.

In addition to the economic and political motivations, there is some evidence of environmental motivations in the bans on leaded gasoline. In 1995, leaded gasoline was banned in the city of Nizhny Novgorod; two years later the Deputy Governor for the Environment of the Nizhny Novgorod region, A. Kosarikov,

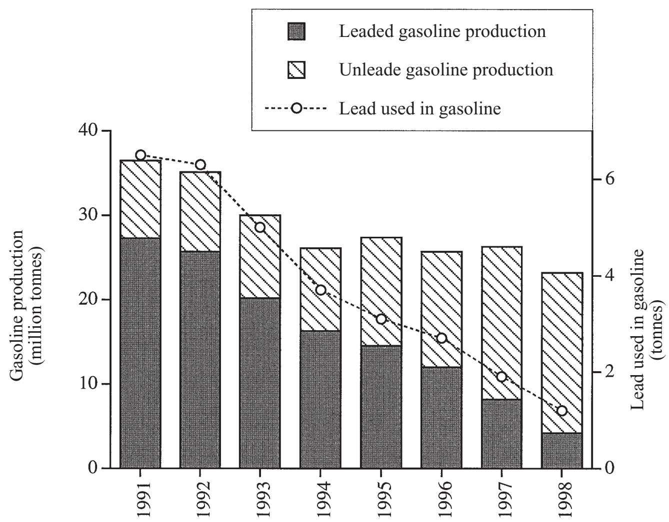


Figure 3. Production of leaded and unleaded gasoline in Russia, and amount of lead used in gasoline, 1991–1998.

Table 3: Production of leaded and unleaded Gasoline at Russian refineries (38, 44).

Location	Gasoline production (million tonnes, ~1990s)	% unleaded 1994	% unleaded late 1990s	Notes
Refineries that supply regions or cities where leaded gasoline has been banned for decades				
				Location of Ban
Moscow	2.2	100	100	Moscow
Kirishi	1.6	99	100	St. Petersburg
Tuapse	0.4	59	100	Crimea
Krasnodar NOS	0.26	89	100	Caucasus
Refineries that supply regions or cities where leaded gasoline has recently been banned				
				Location of Ban
Perm	1.5	79	100	Perm city
Norsi (Nizhni Novgorod)	1.2	39	100	Nizhny Novgorod region
Volgograd	1.0	0	100	Volgograd city
Ryazan	0.6	62	100	Ryazan city
Saratov	0.2	3	77	Saratov city
Novo-Ufa (Novoil)	~1.4	37	100	Bashkortostan
Ufaneftekhim	1.1	0.1	~ 95	Bashkortostan
Salavat NOS	0.8	0	100	Bashkortostan
Ufimsky NPZ	~ 0.7	0	~ 95	Bashkortostan
Khabarovsk	0.3	0.44	100	Khabarovsk Kray
Komsomolsk (Far East)	0.16	0	0	Khabarovsk Kray
Refineries that supply regions where leaded gasoline is not banned				
Omsk	4.2	3.5	31	Exports unleaded to Europe (a)
Angarsk	2.5	0.7	22	
Kuibishev NOS	1.7	18	29	
Yaroslavl NOS	1.4	37	60	
Novokuibishev	1.1	0.7	0.2	
Achinsk (Krasnoyarsk)	1.1	100	100	
Sizran	0.9	12	47	
Kuibishev NPZ	0.86	15	11	
Orsk NOS	0.84	0	0.5	
Ukhta	0.39	100	100	

a: I. B. Bronfin, V. P. Sibneft Oil Co., 1998, pers. comm.

reported that the ban had significantly reduced emissions of harmful compounds to the air, and announced an extension of the ban on leaded gasoline to the entire Nizhny Novgorod region (42).

The decrease in total gasoline production, brought on by the collapse of the Soviet economy, has actually made the phase-out of leaded gasoline easier. Russian refineries can run their catalytic reformers at full capacity while their through-put of gasoline is running at only about half capacity, thus producing gasoline with a higher octane than they would otherwise be able to produce. For example, because the Khabarovsk refinery is operating at 35% capacity, it can produce 100% unleaded gasoline at low to moderate octane levels (A-76, A-92, and A-93) using catalytic reforming alone (V. N. Styazhkin, Chief Engineer, Khabarovsk refinery, 1999, pers. comm.).

Changes in the availability of crude oil or in the demand for gasoline may result in increased use of lead additives in Russia. If more crude oil were available, Khabarovsk refinery officials report that they would resume production of some leaded gasoline, to sell it in the neighboring region, Primorskii Krai, where leaded gasoline has not been banned. On the other hand, due to a short-fall in crude oil deliveries to the Nizhny Novgorod refinery in the winter of 1999, the Nizhny Novgorod government allowed temporary production and sale of leaded gasoline, from January 21 to 1 April 1999 (45).

The transition to unleaded gasoline in Russia seems to have little correlation with the age or technical capacity of the refineries. Notably, the Omsk refinery is the most modern in Russia, capable of producing 100% unleaded gasoline. Yet it still produces mostly leaded gasoline. As can be seen from Figure 4, Omsk is in a region which has not banned leaded gasoline. The Omsk refinery, incidentally, is controlled by the business tycoon, politician B. Berezhovsky. Refinery officials in Omsk report that they have no regulatory or financial incentive to make unleaded gasoline (I. B. Bronfin, V. P. Sibneft Oil Co., 1998, pers. comm.).

In contrast to the regional initiatives, the Russian Federal Government has taken no action to phase-out leaded gasoline. In March 1998, Roscomecologia, the federal environmental agency, proposed a series of measures to reduce use of lead in gasoline (46), but no action was taken. One month later, officials of Roscomecologia stated their opposition to the phase-out of lead in gasoline. The concern of Roscomecologia officials is that even though Russia could produce enough unleaded gasoline for the entire country, this would force some of the less modern refineries to shut down. Roscomecologia officials proposed continued production of leaded gasoline as long as possible, keeping all existing refineries operating at partial capacity, and continued production of leaded gasoline for export even after leaded gasoline is no longer used in Russia. They were opposed to the regional initiatives to restrict leaded gasoline use, because this is making it increasingly difficult to maintain markets for leaded gasoline in Russia. For the same reason, Roscomecologia was also opposed to taxes on leaded gasoline or other measures which would discourage use of leaded gasoline (M. S. Gaygerov, Roscomecologia, 1 April, 1998, Moscow, pers. comm.). While we have no information on the details of policy formation on this issue, it seems that the support for continued use of leaded gasoline is based on concern for those refineries that are still producing primarily leaded gasoline, the largest of these being the refineries in Omsk, Angarsk, and Kuibishev.

In summary, leaded gasoline is being phased out in Russia, despite the inaction, and possible obstruction, at the federal level. The regional initiatives to ban leaded gasoline reflect the growing political and economic autonomy of the Russian provinces. The devolution of authority from the federal government to the provincial governments has included both negotiated treaties, and *de facto* assumption of authority by regional governments (47, 48). Refineries as a whole do not seem to have been strongly opposed to banning of leaded gasoline. In fact, a number of refineries seem to be in cahoots with their regional governments in banning leaded gasoline, over the objections of the federal government. Environmental NGOs seem to have played little role in these developments.

ROLES OF SCIENCE AND POLITICS IN ENVIRONMENTAL MANAGEMENT

This case study of lead pollution illustrates a number of features of science and politics in Soviet and post-Soviet environmental management.

Anti-Soviet politics and the Soviet environmental movement have been closely allied. The environmental movement was more anti-government than anti-industry, and the political movement overall was largely anti-technocratic. This has affected the assessment of environmental problems in a number of ways. The environmental situation in the former Soviet Union, while bad, may not be as horrendous as it has been portrayed. There are even examples—leaded gasoline and lead-based paint—in which Soviet environmental policy was more effective than early US environmental policy.

In eastern Europe, reports of severe environmental problems have been shown to be in some respects exaggerated. In a study of urban air pollution in eastern Europe, Hughes found that average concentrations of particulates and sulfur dioxide are within European Community standards and below the levels found in some western European cities. Acidity in rainwater in eastern Europe's most affected countries, Czechoslovakia and Poland, is no worse than in western Germany and Sweden (49).

Figure 4. Production and use of unleaded gasoline in Russia, by region and by refinery (1995). Data from Table 3. Green shaded regions have banned leaded gasoline in the major cities; green hatched regions have banned leaded gasoline entirely. Pie charts show refinery locations, with red slice indicating fraction of total gasoline production that is leaded gasoline, and green slice indicating fraction of total gasoline production that is unleaded. The area of the pie chart is proportional to the total gasoline production of the refinery. Regions are given in italic font.

On the other hand, it may be important that the two positive achievements of Soviet environmental policy discussed here both took the form of bans. Rather than being characteristic of Soviet environmental management, these two examples may show the relative effectiveness of bans, especially in situations with little or no environmental oversight.

The Soviet legacy of poor environmental data does not seem to have been exaggerated. Basic information on industrial production is still classified, and quality control of environmental measurements is ineffective. Without a firmer foundation, it is difficult to make any kind of assessment of the environmental situation in the former Soviet Union.

The weakness of environmental data is to some extent a reflection of a nonreductionist emphasis in environmental management in the former Soviet Union. In the US, much of the political and ideological debate about the environment is expressed in terms of arguments about science, and in terms of the economic consequences of environmental regulations. In the Soviet model, in contrast, there is little use of science as a proxy for ideological or economic battles. While a nonreductionist environmental approach may have benefits, a consequence is that there is little political incentive to improve environmental science. Moreover, the Russian emphasis on environmental contamination rather than human exposure is reflected in an emphasis on measurement of pollutants in the environment rather than in human populations.

Regional governments are increasingly taking the initiative, in environmental policy as well as other aspects of policy. It is ironic that while the US State Department and EPA have provided significant environmental assistance to the Russian federal government to address lead pollution, the Russian government has taken no action to address the issue, and seems to be working to prevent the phase-out of leaded gasoline. Meanwhile, the provincial governments, with no international assistance, have in a number of cases taken effective action to eliminate leaded gasoline.

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