

Reassessing Past European Gasoline Lead Policies

For the foreseeable future, the atmosphere and the environment will remain a dumping ground for various anthropogenic substances. Some substances will have negative properties, and society will sooner or later begin regulating their emissions. To that end, science must provide society with the tools for retrospectively evaluating the physical and economical impacts of past regulations, and for evaluating scenarios in which alternative future regulations are implemented.

A tool for reconstructing lead air concentrations and depositions across Europe from 1958 through 1995 has been developed that incorporates detailed emissions, a regionalized history of weather events, and an atmospheric transport model. This tool was used, in conjunction with lead measurements in both biota and human blood and with economic analysis, to assess past European gasoline-lead regulations. Some of the specific questions asked in this assessment were: How did lead emissions, atmospheric concentrations, and depositions develop since the 1950s? Was the decline in air concentrations matched by corresponding declines in plants, animals, and humans? Did the regulations result in considerable economic burdens in Germany, for example?

There were several reasons for choosing gasoline lead additives as the basis for a case study of European emission regulations. First, lead emissions underwent significant changes; there was an unabated increase in lead concentrations followed by a post-1970s series of sometimes drastic reductions. Thus, there is a strong and well-defined signal to be detected. Second, once released into the atmosphere, lead accumulates and persists indefinitely in some environmental compartments such as aquatic sediments. What might the ecological and human health impacts of this neurotoxin's environmental distribution be? Finally, airborne lead behaves to a first order approximation as inert, so simulating its transport and deposition is relatively simple. In principle, our tool can be used for any other particle-bound substance of limited reactivity.

This approach proved successful for describing the temporal evolution of the spatial distribution of lead concentration and deposition in Europe. Demonstrating the effectiveness of gasoline lead policies, the reconstructed concentrations in the atmosphere, in plant leaves, and in human blood show a steady decline since the early 1980s, while concentrations in

marine organisms along the North Sea coast, however, seem unaffected to date. Contrary to initial expectations, the German mineral oil industry was not negatively affected. While competition conditions changed in the German gasoline and automobile markets, no impacts of the regulations could be identified in the macro-economic indicators.

European Regulation of Gasoline Lead Additives

Air pollution problems introduced by automobile traffic in the 1960s, of which the most visible was urban smog, were addressed in the United States by the 1963 Clean Air Act. In Europe, serious concern about the effects of air pollution on human health first surfaced in the 1970s. Lead, in particular, added to gasoline for its anti-knock properties, was perceived as a health threat at this time, given new evidence of its neurotoxicological effects, which are especially severe in children. After lead-based paint and lead solder in water pipes and food cans was prohibited, gasoline lead—tetraethyl

and tetramethyl lead additives—became the next target.

In the 1970s, the German government was the first in Europe to regulate lead additives in gasoline. A maximum content of 0.4 g Pb/l was imposed in Germany in 1972—down from the usual 0.6 g Pb/l—which was lowered further to 0.15 g Pb/l in 1976. A preliminary analysis of newspaper coverage shows that gasoline lead-induced health risks were first reported in the German press in the 1960s. Articles in the British press focused not on lead, but on urban smog. And in 1972, a group of French government experts did not acknowledge that any automobile emissions were dangerous (see von Storch *et al.* [2002]). The European Union (EU) fixed its limit modestly at 0.4 g Pb/l, beginning only in 1981, and prohibited all countries from stipulating national limits lower than 0.15 g Pb/l (Council Directive 78/611/EEC of 1978) [Hagner, 2000].

In the 1980s, discussion of automobile air pollution in Europe moved to concerns about forest protection due to the effects of massive NO_x, CO, and C_xH_y emissions. This discussion was also initiated by Germany, where citizens were concerned with the serious deterioration of their beloved forests due to acid rain and photo-oxidation. In 1985, Germany passed a law to reduce total automobile emissions. This law led to the introduction of unleaded gasoline, because the largest reductions of NO_x, CO,

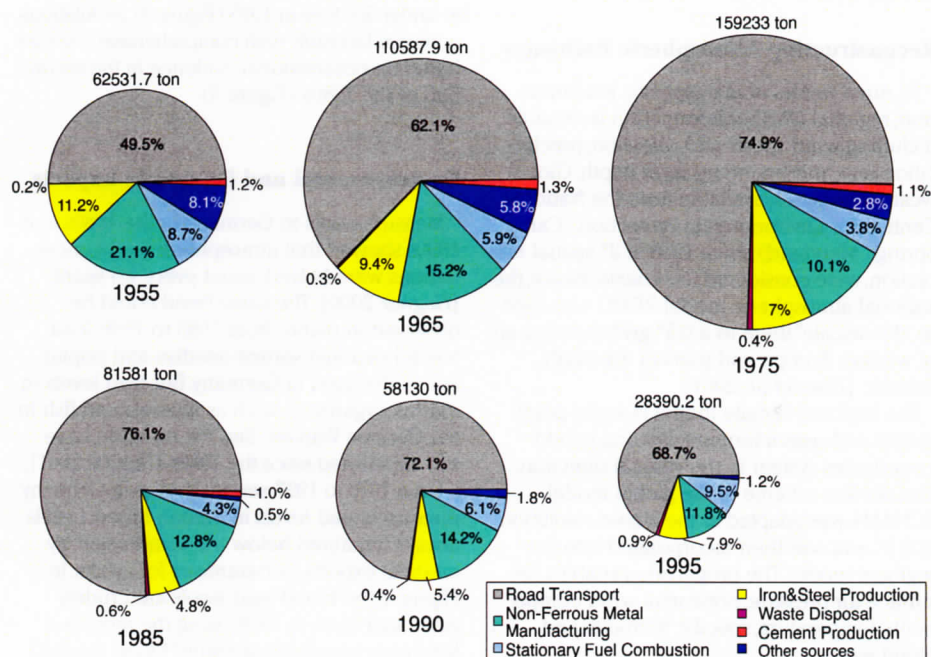


Fig. 1. European lead emissions estimates are listed by source category (from Pacyna and Pacyna [2000]).

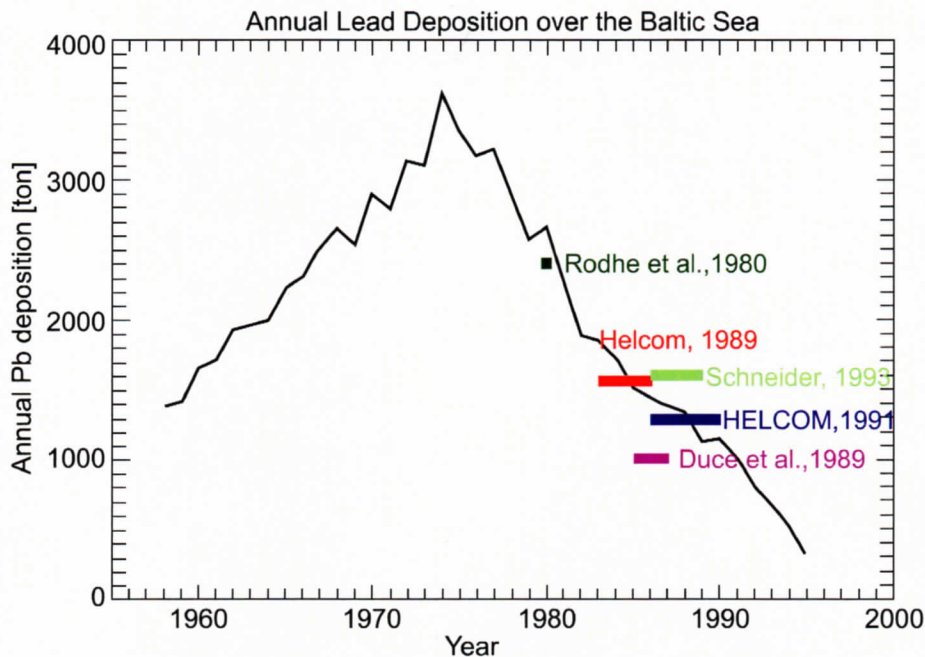


Fig. 3. The input of lead into the Baltic Sea is simulated (line), and estimates based on comprehensive analyses of observational data (colored bars) are also shown.

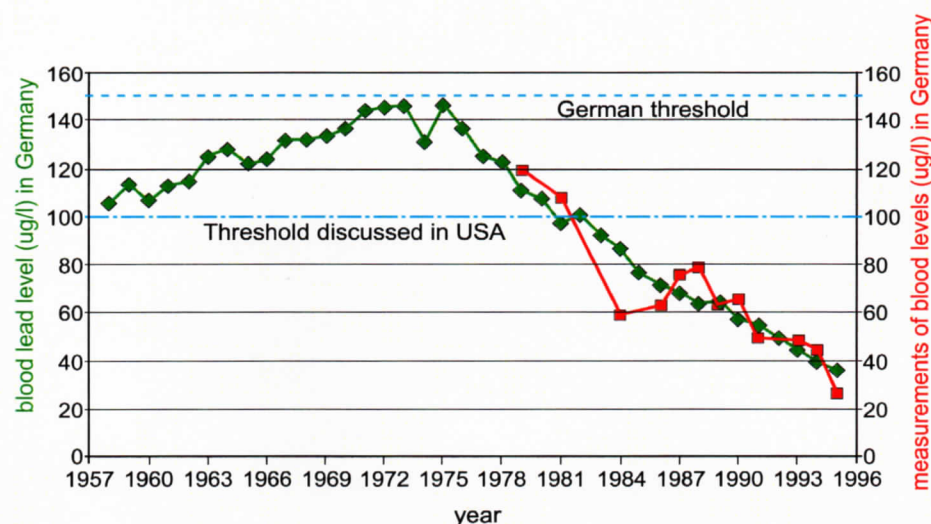


Fig. 4. Lead concentrations in the blood of adults in Germany are plotted; red indicates recorded values and green indicates estimated values.

compartment, once considerable substance amounts have already been released. For those anthropogenic substances that persist for a long time in the environment, that are subject to bioaccumulation, and whose main route of human exposure is the food chain, late emission regulations may be ineffective for protecting human health. In such cases,

the principle of prevention, by which any significant releases are precluded from the start, may be appropriate.

One should, however, not forget that the large amounts of lead emitted in the past 50 years have not simply vanished but now reside for good—and are ubiquitous—in the global environment. The use of lead in gasoline was indeed

a large-scale geophysical pollution exercise, and it remains to be seen if long-term effects may later emerge.

In the future, the modeling system needs to be extended by modules; by describing the transport in river catchments and channels; and through substance transformations, depositions, and resuspension, and the interactions with the ecosystems. Furthermore, the methodology should be applied to other substances; candidates include persistent organic pollutants, radioactive substances, some other heavy metals, and pollens, among others. Because of the increased complexity with respect to such substances, in particular concerning chemical transformations, cooperation partners are sought.

For additional information, see Web site: <http://w3g.gkss.de/staff/blei>. The annual emissions and modeled concentrations and depositions data are available for download from a link on this page.

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