AN EFFORT TO INVENTORY DIOXIN RELEASES TO AIR AND DIOXIN LEVELS IN RUSSIA'S ENVIRONMENT

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I. Introduction

Dioxin contamination in Russia presents an environmental and public health risk, nationally and globally. Dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) have been characterized in humans and in animals as highly toxic and highly persistent with the ability to bioaccumulate in the food chain. Specific congeners are classified as carcinogens. On one hand, the levels being released into the environment from industrial sources in Russia are elevated compared to other industrialized countries. On the other hand, there are no current efforts to reduce the sources or protect public health. A necessary first step in rectifying this situation in Russia is to clearly define the problem using validated methods.

An inventory of dioxin emissions and environmental levels in Russia was recently initiated with the objective of answering the following questions: 1) what are the significant sources of dioxin in Russia currently and 2) can we develop the necessary methods (analytical, mathematical, observational) to estimate total annual emissions? The project was designed with the additional objective of building the capacity of Russian analytical laboratories and other specialists to carry out this work. We conducted a training in the spring of 2000 in U.S. laboratories for a team of analytical chemists from Russian laboratories. This was followed by an inter-calibration between the Russian labs to check the accuracy of their dioxin analyses.

Extensive outreach was done to regional administrations, industry representatives, and non-governmental environmental organizations to collect information as well as raise awareness on the problem of dioxin contamination. This paper reports the results of the first phase, carried out with financial assistance from the Office of International Activities of the United States Environmental Protection Agency and the Trust for Mutual Understanding. Information will be shared on cost-effective methods to conduct a national dioxin inventory as well as some of the institutional, technical, and financial challenges that have been encountered in the process.

II. Methods

To base a dioxin inventory on direct measurements of releases to the environment is prohibitively expensive and technically infeasible for Russia. There are only 4 laboratories in Russia which have the necessary instrumentation and expertise to conduct high-quality dioxin analysis. Each analysis can cost from $500-1000 not including sample collection and transportation.

As a solution to this problem, we worked as much as possible with existing data. We searched the literature for methods of estimating emissions based on available data. We gained access to all data generated under the Federal Dioxin Program in Russia, as well as regional dioxin assessments carried out by scientific institutes. We used these data, governmental statistics on industrial production volumes and waste generation, and published emission factors. A representative of the Russian chlorine industry provided current data on production volumes and dioxin emissions for 7 Khimprom facilities. We estimate annual emissions from a total of 9 source categories ranging from 2,4-D production to forest fires (see Table 1).

In addition, we collected 40 environmental samples from remote regions of Russia. We chose sediment and soil to give us an idea of long-term contamination of land and water. Butter was used an indicator of short-term atmospheric transport and deposition. We also analyzed samples of incinerator ash and sewage sludge to assess specific sources. All of the samples were analyzed in Russian labs using standard GC/MS methods and QA/QC procedures.

In order to build national support and awareness of this effort, we sent a letter to all 89 regional administrations in Russia requesting their participation in sample collection and funding of the analyses. We had a 44% response rate. The majority of respondents sent a sample of soil, sludge, sediment or butter collected according to our protocol. These samples are being stored in Moscow and we will continue to analyze them as funding permits.

A Russian non-governmental organization participated by sending a questionnaire to 270 addresses in 39 regions or Russia to collect qualitative data to be used in the inventory. The questionnaire asks local environmental groups and active citizens to describe waste holding ponds and other types of unregulated, unsanctioned disposal of industrial wastes in their communities. They are asked to describe landfills and waste dumps for municipal garbage. The responses to this questionnaire are being used to complete a national database on potential sources of dioxin. The mailing itself included information on dioxin and other persistent organic pollutants, information on the two international agreements to eliminate POPs, and suggestions for action to reduce POPs exposures.

We have potentially underestimated emissions from some source categories and overestimated others. This is an artifact of the many assumptions we were required to make in the face of incomplete data. We make assumptions on the composition of industrial waste being disposed of, methods of disposing of waste (based on common practices), and industrial practices which are poorly documented in publicly available documents. We conducted extensive research on appropriate emission factors for dioxin emissions which can be applied to Russian technology. Those which we have the most confidence in are listed in Table 1. It is our intention in the next phase to validate the use of these emission factors with direct measurements.

III. Results and Discussion

The annual estimate of dioxin emissions to air in Russia ranges from **6,917 to 10,835 grams I-TEQ/yr**. The extremely high estimate of 10.8 kg is attributable to the burning of industrial hazardous wastes. According to the 1998 Russian Governmtal Report on the State of the Environment, 42.4 million tons of hazardous wastes were "disinfected" (5) which in current Russian conditions means burned without any emission control. For this reason, we use a high emission factor of 240 ng of dioxin/kg of waste burned (4) to get an estimate of 10.1 kg I-TEQ/yr for this category alone. This annual estimate does not include emissions from metallurgical and cement industries which are known to be sources of dioxin. We estimate an additional contribution of 1-3 kg I-TEQ/yr from these sources.

The 10.8 kg estimate is two to three times higher than any single country estimate as reported by UNEP Chemical for the year 1995 (15). It is roughly equivalent to the U.S. emission estimate for 1987 before regulations were tightened on incineration and other dioxin-generating industries (2). The low end estimate is based on emission factors which are not specific to Eastern European technologies. The high end estimate is based on emission factors which may be more accurate for the state of Russian industrial technologies and practices (3).

These results make the case for immediate action to enforce regulation on the treatment of industrial waste. All of these estimates will be further refined in the next phase of the project which will consist of direct measurments from industrial smokestacks.

We divided the environmental sampling according to 6 geographically distinct regions of Russia. For each region, our sample sizes are too small to draw general conclusions on environmental levels in that region. However, we do observe general trends in background levels of dioxin in soil and sediment in urban, industrial and rural areas of Russia. In some areas, we report exceptionally high concentrations in soil near combustion sources and chemical manufacturing. In a soil sample from a residential area of Vladivostock which is 500-1000 meters from a municipal waste incinerator, we saw concentrations of dioxin as high as 407.8 ng I-TEQ/kg soil. This exceeds the commonly used standard for residential areas by 8 times (10). We found levels of dioxin in sediment taken from the Northern Dvina River in Arkhangelsk, directly downstream of a paper and pulp mill outfall pipe to be as low as 0.6 ng I-TEQ/kg (6).

We report dioxin levels for regions of Russia which have never been investigated such as Kostroma, Pskov, Kurgan, Chita, Saratov, Karelia, Udmurtia, Dagestan, and others. The dioxin concentrations in butter demonstrate that the atmospheric transport of dioxin has led to detectable background levels of dioxin in rural areas. In proximal areas to dioxin sources, levels in butter are elevated.

These data have identified dioxin "hot spots" where action should be taken immediately to reduce the risk of human exposures.

TABLE 1
Estimate of Annual Air Emissions of Dioxins in Russia

Source Category	Volume	Emission Factor (I-TEQ)	Total Annual Emission (g I-TEQ/year)
Chemical Production of Chlorinated Substances*:			
Amine Salt 2,4-D	20,000 tons	2.4 ng/kg ***	0.04
Chlorinated solvents	140,000 tons	0.95ng/kg ***	0.13
Incineration of Industrial Chemical Wastes			
Chapaevsk			3.5
7 Khimprom plants	145,251 tons	min 4.8 ng/kg max 45 ng/kg	0.7 * 6.54
Subtotal		*Min:*	***4.37***
		Max:	***10.21***
High temperature processes			
Combustion of Coal	232 million tons (1998)	**min**: 1 ng/kg** **max**:1.4 ng/kg ***	232 325
Incineration of Municipal Wastes (only Moscow and Murmansk)	237,000 tons	**min**: 150 ng/kg** **max**: 240 ng/kg#	35.6 56.9
Incineration of hazardous organic wastes (including chlorinated)	42.2 million tons*	**min**: 150 ng/kg** **max**: 240 ng/kg#	6,330 10,128
Automobile transport	Unleaded- 8 million tons Leaded- 15.8 million tons Diesel fuel-43 million tons	1 ng/kg 9 ng/kg 1 ng/kg	8 144 43 **Σ 195**
Forest fires	143 million cubic meters (1998)	1 ng/kg wood**	120
Subtotal		Min:	***6,912.6***
		Max:	***10,824.9***
TOTAL FOR RUSSIA		Min:	**6,916.97**
		Max:	**10,835.11**

* Estimate of SPA "Typhoon"
** Data from UNEP Chemical
*** Experimental Data of SPA "Typhoon"

IV. Recommendations and Outlook

A meeting was hosted by UNEP Chemical and the Ministry of Natural Resources in Moscow from March 27-29, 2001 to discuss the results of the first phase of the dioxin inventory and plan the next phase. The next phase of the project will be undertaken as part of the Arctic Council Action Plan, with funding contributed from the 8 Arctic countries. In the near future, the University of Umea in Sweden will host representatives of the Russian laboratories for a training in the sampling and analysis of smokestack gas emissions. The Arctic Council plan consists of 1) further identification and characterization of dioxin sources 2) assessment of the technological processes which are generating dioxin and 3) implementation of a demonstration project on source reduction (16).

The governmental body that held the responsibility for the regulation of dioxin, the State Committee on Environmental Protection, was closed in December 2000 by an order of the Russian President. The Russian Ministry of Natural Resources is in the process of taking on these responsibilities and setting a policy agenda for persistent organic pollutants (POPs). The dioxin inventory is viewed as a tool for prioritizing investments in source reduction and setting regulatory standards for dioxin in Russia. Pressure is mounting on the Ministry to sign two recently negotiated international agreements on persistent organic pollutants (POPs). By completing this inventory and publishing the results internationally, Russia could become a leader among the former Soviet bloc countries in the effort to rid the planet of POPs contamination.

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