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"Dioxin and Furan Releases and their Risk Assessment on the Population Health in some regions of the Russian Federation"

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I. INTRODUCTION

- **Centre for International Projects** activity (2001-2004) in the framework of Project "Reduction/Elimination of Dioxin and Furan emissions in the Russian Federation with Focus on the Arctic and Northern Regions Impacting the Arctic" (Arctic Council Action Programme) jointly with Professor Y. A. Treger and Doctor V. N. Rozanov.

- **Chair of the Steering Group** of this Project is the representative of Sweden.
  Financing of the Project was provided by US EPA and Swedish EPA.

- "**Russian Statistical Year-Books**, 2001-2003", "Industry of Russia, 2002-2003", "The State Report on Environment Condition and Protection in the Russian Federation in 2001-2003", the monography "Dioxins in Russia" (2001), "UNEP Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases" (2001-draft, 2003-first issue), information from the Committees for Natural Resources of Arkhangelsk, Murmansk regions, the Republic of Komi.

- **Evaluation** only dioxin releases into atmosphere.
- **Dioxin** supply with sewage, solid wastes and products has not been considered in the presentation.

- **Experimental data** was carried out by Russian Research and Development Centre for Emergency Situations of the Ministry of Health having relevant international intercalibration and accreditation of the State Standard of Russia.

- **The estimation of risk** for population health has been carried out by the Scientific Research Institute of Hygiene, Toxicology and Professional Pathology of the Ministry of Health and Social Development of the Russian Federation.

Arkhangelsk region – 1- Onega, 2-Severodvinsk, Novodvinsk, 3-Mezan
Murmansk region – 1-Zapolyarniy, 2-Nikel, 3-Severomorsk, 4-Monchegorsk, Olenegorsk, 5-Appatity, Kirovsk, 6-Kandalaksha
Republic of Komi – 1-Ukhta, 2-Sosnogorsk, 3-Borkuta

Table 1

Statistic data on Arkhangelsk and Murmansk regions and on Republic of Komi (January, 2003)

№	**Region** / **Statistic data**	**Arkhangelsk region** (Arkhangelsk)	**Murmansk region** (Murmansk)	**Republic of Komi** (Syktyvkar)
1	Population (thousand persons)	**1429**	**988**	**1126**
2	Area (thousand km^2)	**587, 4**	**144,9**	**415,9**
3	Number of enterprises in industry	**2734**	**2431**	**2397**
4	Releases into atmosphere from stationary sources (thousand tons)	**1060**	**2077**	**1136**
5	Caught pollutants from stationary sources (thousand tons)	**764**	**1753**	**451**
6	Discharged polluted wastes into surface water bodies (mln m^3)	**539**	**372**	**572**
7	Produced toxic wastes, (thousand tons)	**322**	**469**	**3700**
8	Among these used at enterprises (thousand tons)	**65**	**281**	**185**

Table 2

Manufacturing in the industries – potential sources of dioxin releases as on 2002

№	Region / Statistic Data	Arkhangelsk region	Murmansk region	Republic of Komi
1	Oil production, including gas condensate (thousand tons)	**4586**	–	**9158**
2	Gas production (mln m^3)	**338**	–	**3798**
3	Coal production (thousand tons)	–	**292**	**18777**
4	Power generation (billion kW-hours)	**6,3**	**16,7**	**8,4**
5	Extraction of iron ore (mln tons)	–	**7,5**	–
6	Steelmaking (thousand tons)	**5,5**	**11,5**	**0,3**
7	Production of sulphuric acid (thousand tons)	–	**198**	–
8	Synthetic resins and plastics production (thousand tons)	**5,2**	–	**15,5**
9	Wood production (thousand m^3)	**9114**	**96,6**	**4971**
10	Timber production (thousand m^3)	**2090,9**	**31,5**	**687**
11	Cellulose production (thousand tons)	**1752**	–	**480**
12	Paper production (thousand tons)	**301**	–	**500**
13	Cardboard production (thousand tons)	**627**	–	**131**
14	Cement production (thousand tons)	**327**		**146,7**
15	Building brick production (mln standard bricks)	**28,7**	**6,2**	**47,7**
16	Textile production (mln m^2)	–	–	**78,9**
17	Knitwear production (thousand pieces)	**3**	**3**	**4**
18	Shoemaking (thousand pairs)	**66**	**30**	**105**

II. Main sources of dioxins/furans.

Arkhangelsk and Murmansk regions and Republic of Komi are pilot regions for the presentation**.**

The following **activity** was implemented:

- Consideration of the Industries and the main enterprises, in which technological **processes formation of dioxins and furans** is probably possible.
- Determination of the **volumes of output** of products or consumed crude materials necessary for **estimation** of dioxin emissions.
- Determination of the **technological parameters** of manufactures influencing formation of dioxins and furans.
- Selection of **factors** of dioxin emission with a view to 1 ton of released production or consumed crude material.
- Determination of **intervals** of possible changes of factors of dioxin emission.

The **selected factors** of dioxin emission can deviate to one or another direction from true value by **two reasons**:

· dioxin emission strongly **depends** on little **changes of parameters** of technological process and **presence of pollutants** in a burnt component;

· deeper familiarization with **technology of each concrete process**, and in some cases an **experimental estimation** of emissions is required for a correct selection of the emission factor.

Table 3

Contribution of various categories of dioxin and furan sources into the total releases in 2001

№	Source of dioxin and furan releases	Regions					
		Arkhangelsk region		**Murmansk region**		**Republic of Komi**	
		mg TE	%	mg TE	%	mg TE	%
1	Pulp-and-paper industry	3907	46,1	-	-	240	5,5
2	Non-ferrous metallurgy	-	-	1280	14,2	-	-
3	Electric and heat-and-power engineering	780	9,2	219	2,4	1083	25,0
4	Housing and communal services (HCS)	664	7,9	153	1,7	502	11,6
5	Extraction and processing of hydrocarbon material	3	~0,0	4	~0,0	296	6,8
6	Ferrous metallurgy	16	0,2	935	10,4	-	-
7	Building materials industry	1148	13,6	5	0,1	802	18,5
8	Transport	684	8,1	382	4,3	435	10,0
9	Burning of solid household wastes (SHW)	-	-	5400	60,1	-	
10	Forest fires	1265	14,9	610	6,8	980	22,6
	Total	8467	100,0	8988	100,0	4338	100,0

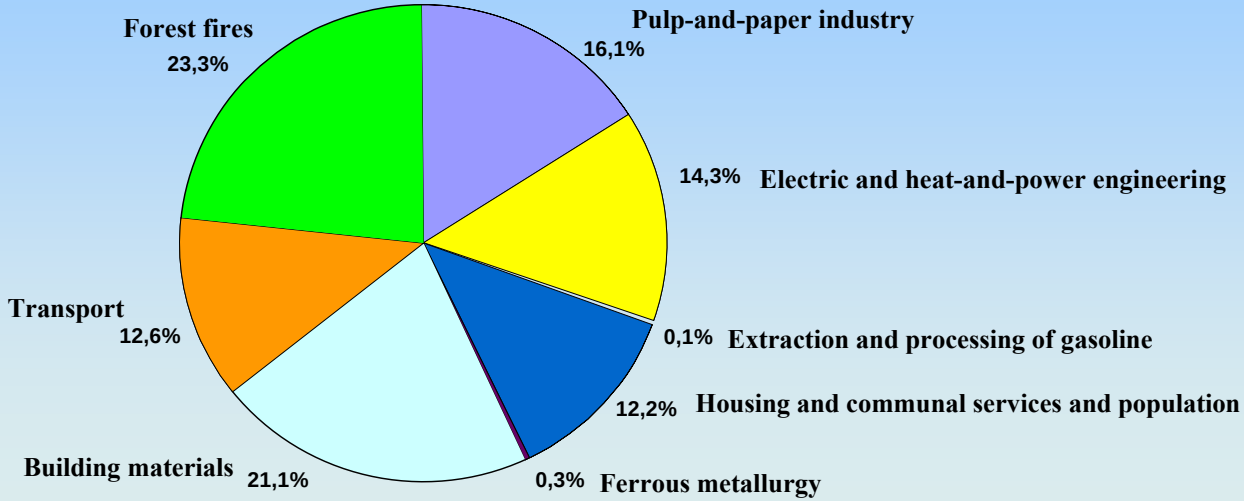
mg TE – milligram of toxic equivalent

Estimated dioxin releases into atmosphere **in 2001** are determined using the data on volumes of output of products or consumed crude material, as well as selected emission factors:

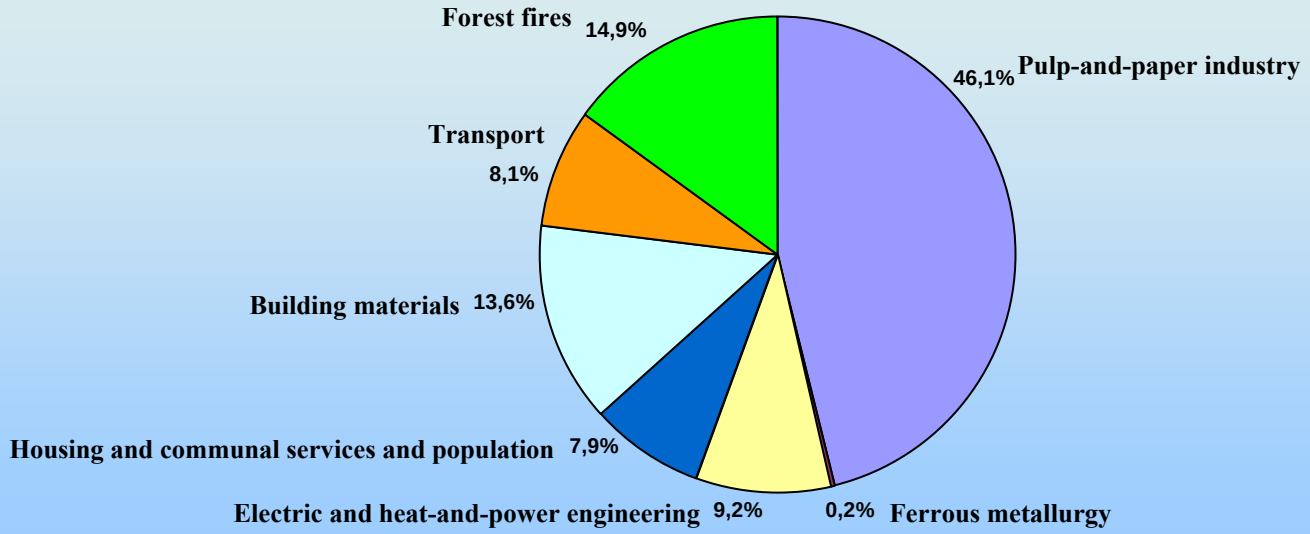
- **Arkhangelsk region** ~ **5,4** g TE (received taking into account– **8,5** g TE)
- **Murmansk region** ~ **8,4** g TE (received taking into account– **9,0** g TE)
- **Republic of Komi** ~ **4,2** g TE (received taking into account– **4,4** g TE)

Fig.1 Arkhangelsk region in 2001-2002

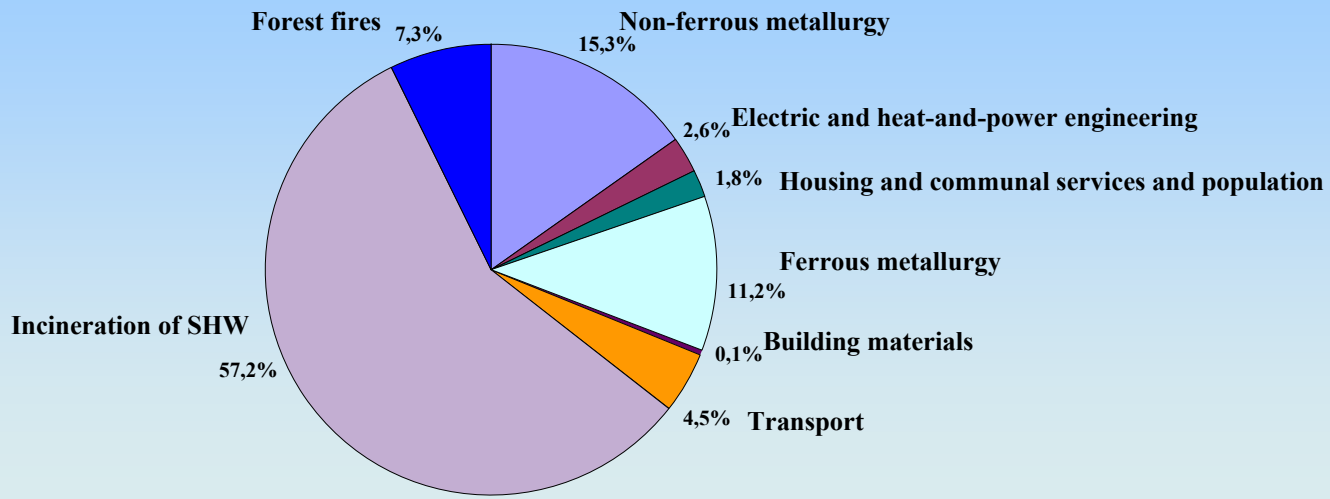
Estimated contribution of various sources of dioxins and furans into total releases



Contribution adjusted taking into account measures



Estimated contribution of various sources of dioxins and furans into total releases



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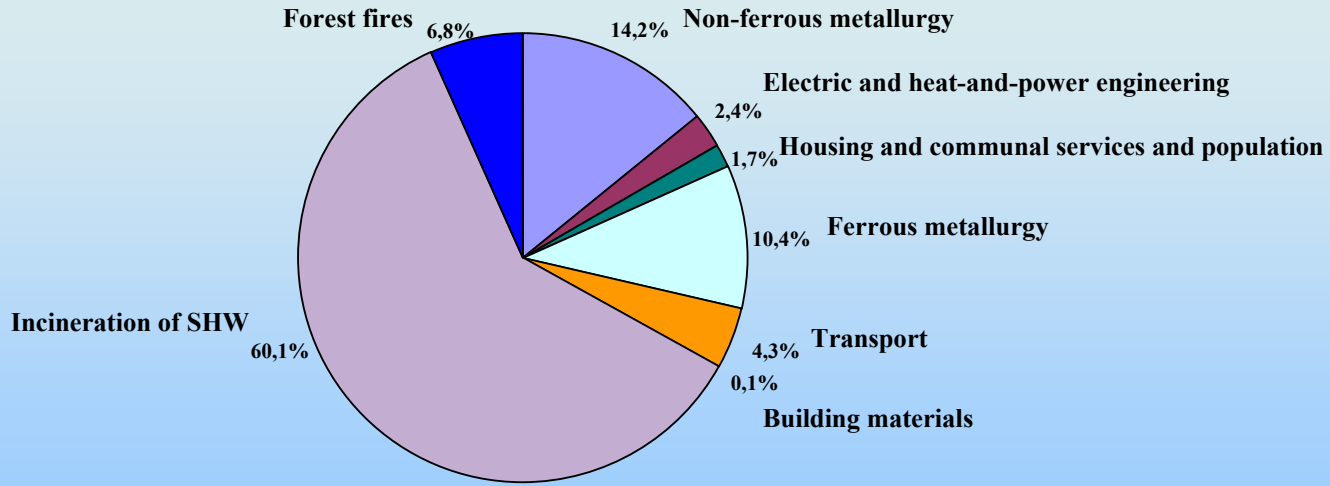
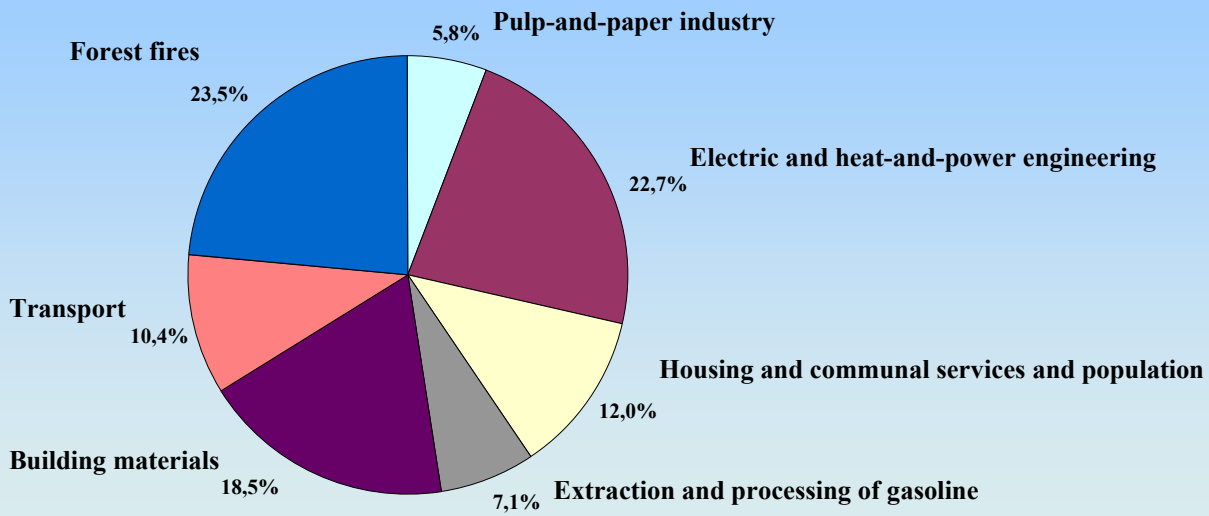


Fig.3 Republic of Komi in 2001-2002

Contribution of various sources of dioxins and furans into total releases



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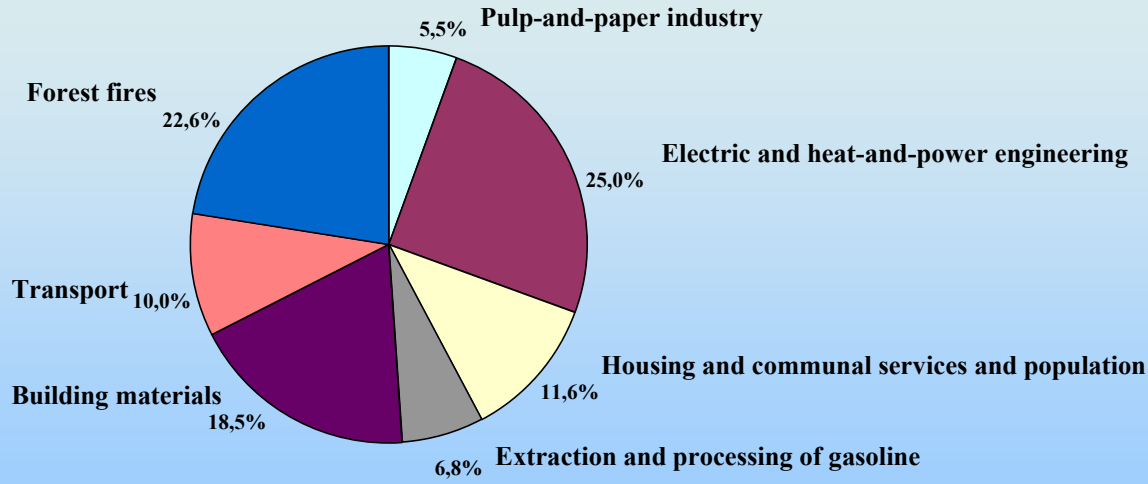


Selected enterprises:

• Murmansk incineration plant;
• Kotlass Pulp-and-Paper Mill (Arkhangelsk region);
• Vorkuta cement plant (Republic of Komi);
• Vorkuta thermal power station (Republic of Komi).

Researches were conducted in **two stages**:

• Calculation data based on the information of the enterprises;
• Experimental research based on measures of gas releases that allowed definition experimental dioxin emission factors.

❖ Experimental dioxin emission factor for incineration of solid household wastes for **Murmansk incineration plant** (**45 μg TE/t of SHW**) has **almost coincided** with the recommended value (**40 μg TE/t of SHW**) (UNEP Toolkit);
❖ Experimental emission factor for incineration of alkali liquor for **Kotlass Pulp-and-Paper Mill (0,57 μg TE/t** of incinerated crude material) **turned out to be ~ 8 times higher** than the recommended value (in the same place) of emission factor (**0,07 μg TE/t** of incinerated crude material);
❖ Experimental dioxin emission factor for **Vorkuta cement plant (5,2 μg TE/t** of cement) has also **coincided** with the recommended value (**5 μg TE/t** of cement);
❖ Experimental emission factor for incineration of coal for **Vorkuta thermal power station (0,57 μg TE/t** of coal) turned out to be **1,6 times higher** than the recommended value (**0,35 μg TE/t** of coal) that is well enough coincidence in specialist opinion.

The replacement of recommended values of estimated emission factors with experimentally gained ones have only changed rather significantly data **for Arkhangelsk region**. Dioxin releases for total pulp-and-paper industry **increased from 876 to 3907 mg**, and **total dioxin releases** for the region **increased from 5436 to 8467 mg** or to ~ **8,5 g** (Table 3).

Dioxin releases at the **Murmansk** incineration plant increased **from 4800 to 5400 mg**, and that for all sources **in Murmansk region from 8388 to 8988 mg** or to ~ **9 g** (Table 3).

Dioxin releases at the **Vorkuta** thermal power station increased **from 213 to 350 mg**, and Vorkuta cement plant – **from 735 to 764 mg**. As a result **total dioxin releases in the Republic of Komi** increased **from 4173 to 4339 mg** or to ~ **4,4 g** (Table 3).

Industries with no dioxin releases into atmosphere discovered (or no data)

I GROUP – includes subbranches, for which **dioxin formation is not occurred**, and, most probably, on the basis of available knowledge of production technology **no dioxins are formed or released:**

- Natural gas production;
- Primary oil refining with distillation;
- Extraction of various ores and their enrichment without calcinations.

Such technologies usually use physical methods of production, separation and processing, occurring at relatively low temperatures.

II GROUP – includes branches and subbranches, for which no data on dioxin formation is available, at that dioxin **formation is possible, but rather small**:

- Mechanical engineering and metal working;
- Production of sulfuric acid.

III GROUP – includes subbranches and manufactures, for which data on dioxin formation and/or presence **is available**, but dioxin releases into atmosphere **are estimated as least**:

- Provision and processing of wood;
- Secondary oil refining;
- Production of synthetic paintworks and plastics;
- Production of textile and shoe.

IV GROUP – includes sources of dioxin releases **unrelated with the main industries**, for which emission factors even can be available, but **no quantitative data on release volumes is available**:

- Incineration of various industrial and solid household wastes by burning in dumps and accidental fires.

Table 4

Comparison of experimental, recommended by UNEP Toolkit and published data on factors of dioxin emission in various processes

Enterprise	Fuel	**Experimental emission** factors for incinerating crude material (μg TE/t) researches from 2004	**Recommended emission** factors for incinerating crude material (μg TE/t) UNEP Toolkit	**Published data on emission** factors for incinerating crude material (μg TE/t)
Murmansk incineration plant	Solid household wastes (SHW)	45	40	30-350
Kotlass Pulp-and-paper Mill	Conifer, deciduous alkali liquor	0,57	0,07	0,7-5,4
Vorkuta cement plant	Coal	5,2	5	0,15-24
Vorkuta thermal power station 2	Coal	0,57	0,35	0,25-8

μg TE/t – microgram 10^{-6} of Toxic equivalent/tons

The value of the selected **enterprise** was estimated by the following **criteria**:

- value of contribution into the total dioxin and furan releases

- absence of experimental data on dioxin contents in gas releases at the moment of measurements

- high indefiniteness (wide range) of factor of dioxin emission for this specific source

Table 5

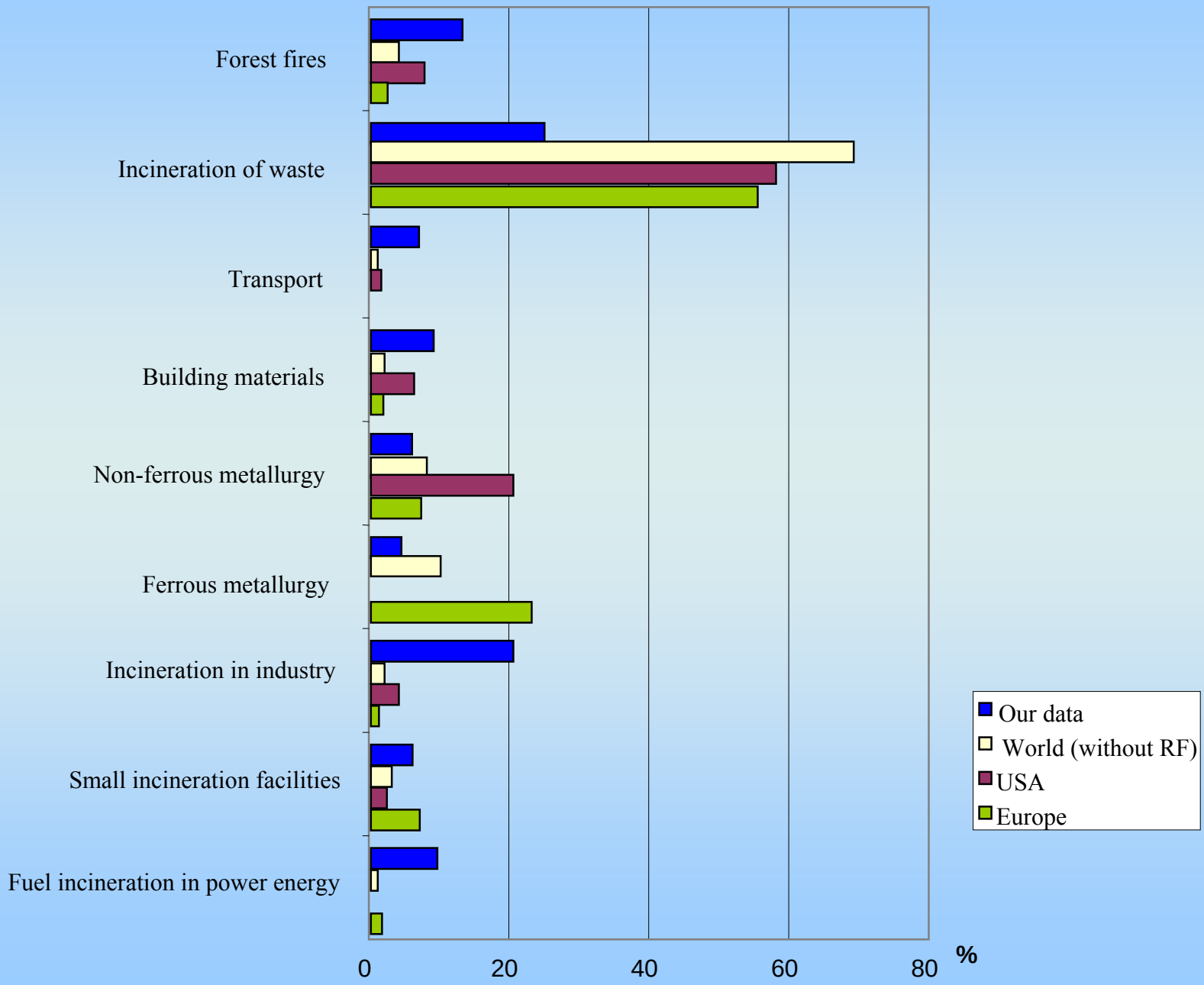
Comparison of factors of various inventories of dioxin/furan releases with data on pilot regions of the Russian Federation, %

№	Sources of dioxin and furan releases	As of 2000			*As of 2001 (taking into account researches of 2004)*		
		Europe	USA	World (without RF)	*Arkhangelsk region*	*Murmansk region*	*Republic of Komi*
1	**Incineration in power energy**	1,6	Not available	1,5	***9,2***	***2,4***	***25,0***
2	Small fuel incineration facilities	7,0	2,3	3	*7,9*	*1,7*	*11,6*
3	**Incineration in industry**	1,2	4,0	2,5	***46,1***	-	***12,3***
4	Separately – ferrous metallurgy	23,0	Not available	10	*0,2*	*10,4*	-
5	Separately – non-ferrous metallurgy	7,2	20,4	8	-	*14,2*	-
6	Manufacture of building materials	1,8	6,2	2	*13,6*	*0,1*	*18,5*
7	**Transport**	0,5	1,5	1	***8,1***	***4,3***	***10,0***
8	Incineration of wastes	**55,3**	**57,9**	**68**	-	***60,1***	-
9	Forest fires	2,4	7,7	4	*14,9*	*6,8*	*22,6*
	Total	100,0	100,0	100,0	*100,0*	*100,0*	*100,0*

When comparing dioxin releases distribution adjusted for experimental data with global tendencies one can note more important contribution in overall picture of releases by the data on **Russian enterprises** connected with **incineration in industry**, **power energy** and **transport**, the least is connected with using of leaded gasoline.

Only the data on Murmansk region **corresponds to world tendencies** as well as the **data on Europe and the USA** where more than half of all releases into atmosphere of dioxins and furans is formed as a result of waste incineration (the **only one** of the Russian regions where the modern **incinerate plant** operates).

Fig. 4 Relative contribution of separate sources into total releases of dioxins, %



Total (adjusted for results of experimental analysis) **sources of dioxin releases** over three considered regions were ranked as follows:

Forest fires – 13,1%;

Incineration of solid household wastes – 24,8%;

Transport – 6,9%;

Building materials industry (cement) – 9,0%;

Non-ferrous metallurgy – 5,9%;

Ferrous metallurgy – 4,4%;

Incineration in industry – 20,4%;

Small incineration facilities (HCS and population) – 6,0%;

Fuel incineration in power energy – 9,5%;

In distribution of dioxin releases by branches adjusted for experimental data, **SHW** (solid household wastes) incineration has maintained the **first place – 24,8%.** The **second place** occupied by releases from **incineration in industry – 20,4%.** Ranking of other sources by dioxin release values remained unchanged in comparison with estimations.

III. Assessment of risk for population health and analysis of dioxin/furan release performance in a number of regions in the Russian Federation

A. The main sources of air pollution are:

Arkhangelsk region:

- Two pulp-and-paper plants, thermal power station, Hydrolytic plant, seven woodworking enterprises – Arkhangelsk
- Pulp-and-paper plant and furniture plant – Novodvinsk
- Thermal power station–1, thermal power station–2, Sevmashenterprise «Zvezdochka», furniture plant – Severodvinsk
- «Kotlass Pulp-and-Paper Mill» and woodworking enterprise – Koryazhma
- Hydrolytic plant and woodworking enterprise – Onega.

Murmansk region

- Thermal power station and, Extractive plant – Apatity and Kirovsk
- Kandalaksha aluminum plant, Thermal power station – Kandalaksha
- Kovdor mining-and-processing integrated works – Kovdor
- Thermal power station and mining-and-processing integrated works – Kola
- Kola mining-and-metallurgical integrated works and «Severonickel» mill (division of «Norilskiy nickel») – Monchegorsk
- Thermal power station and GOUTP «TEKOS» – Murmansk
- Mining-and-metallurgical integrated works «Pechenganickel» – Nickel
- Mining-and-processing integrated works and mechanical plant – Olenegorsk
- Military department enterprise and heating system – Severomorsk

The greatest threat for population health in the region is represented with the following chemical compounds:

ancerogenes – dioxin and compound similar to dioxin, benz(a)pyrene, benz(b)fluoranthene, benz(k)fluoranthene, indene(1,2,3- c,d) pyrene, formaldehyde,

on-cancerogenes – dust PM_{10}, sulphur dioxide, carbonic oxide, nitrogen dioxide, vanadium pentoxide, sulphuretted hydrogen, hydrocarbons, nitrogen oxides, carbon sulphide, methyl mercaptan, methanol.

The greatest threat for population health in the region is represented with the following chemical compounds:

cancerogenes – dioxin and compound similar to dioxin, benz(a)pyrene, benz(b)fluoranthene, benz(k)fluoranthene, indene (1,2,3- c,d) pyrene, formaldehyde, carbon black, nickel, lead, chrome;

non-cancerogenes – dust PM_{10}, sulphur dioxide, carbonic oxide, nitrogen dioxide, vanadium pentoxide, manganese, cupric oxide,

Republic of Komi

- Woodusing industry – Syktyvkar
- Vorkuta cement plant, thermal power station -1 and thermal power station -2 – Vorkuta
- Thermal power station, woodusing enterprise and gas processing plant – Sosnogorsk and Ukhta
- Thermal power station, coal-extractive enterprise and mines – Vorkuta and Inta.

Resume

· **In all large cities and adjoining to them territories the increased content of heavy metals is observed.**

· **Automobile transportation and heating boiler of housing and communal services also is important sources of air pollution in all listed cities of all three regions.**

B. Definition of cancerogenic effect of dioxin impact

Dioxins/Furans are:

- group of extremely toxic substances
- formed at high-temperature chemical engineering processes of chlorination of organic substances
- burning chlororganic compounds, various household, medical and industrial wastes not only on dumps, but also in incinerate furnaces
- organochlorine pesticides brought in ground, exhaust gases of automobiles, products of burning at fires
- produced by mankind in ever-increasing volumes last half a century dioxins

Accumulate in the environment and endanger survival of mankind:

- break a genofund of human populations
- cause a wide spectrum of dangerous diseases (infringement immune and endocrine systems, cancerological diseases, heavy frustration of reproductive function and others)
- half-period of dioxins in ground depending on its characteristic and meteorological conditions - from 8 months to 13 years
- transferred to long distances through air masses
- receipt of dioxins to the person occurs through consumption of the food, air, drinking water and through skin:

  - **Inhalant effect of dioxin** containing in atmospheric air on human being.
  - **Dermal effect of dioxin** containing in soil through human skin.
  - **Oral effect of dioxin** due swallowing of soil particle and dust.

Cancerogenic effect of dioxin impact - risk determined as probability of oncological disease during the life (~70-75 years)

C. Conclusion

1. Pollution of air by emissions of the industrial enterprises, as well as the presence of cancerogenic substances in ground **causes potential risk** of development of chronic diseases and increase of death rate of the population.

2. Inhalant effect of dioxin on the population of all three regions increases the risk of malignant swelling disease **estimated from 1 to 3 per 10 000 people**, that in **100-300 times is higher** than "**comprehensible**" (accepted **in developed countries**) risk level of carcinogenesis which is estimated as 1 on 1 million people.

In Arkhangelsk region most high individual death risk with releases into atmosphere of suspended particles including carcinogenic substances is observed in the following cities: Arkhangelsk, Severodvinsk and Novodvinsk.

In Murmansk region most high individual death risk with releases into atmosphere of suspended particles including carcinogenic substances is observed in the following cities: Monchegorsk, Kirovsk, Olenegorsk, Apatity.

In the Republic of Komi most high individual death risk with releases into atmosphere of suspended particles including carcinogenic substances is observed in the following cities: Syktyvkar and Vorkuta.

Thus, the **analysis of chemical pollution** of atmospheric air and ground by dioxins/furans in these regions allows **to draw a synonymous conclusion** on the increased **risk for health** of the **population**, especial, of **children** which is expressed in opportunity of occurrence of **chronic diseases and malignant neoplasms**.

Thank you for your attention

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