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Dioxins in the environment of Chapaevsk (Russia), health of its population

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1. Introduction. The city of Chapaevsk is situated 43 km from Samara on the bank of Chapaevka river, a tributary to the Volga. The city occupies the territory of 187 km², 51% of which is taken by industrial enterprises, that are mostly units of the military-industrial complex (MIC). In 1989 those enterprises were responsible for 86 % of the city manufactured products and almost half the city work force was employed there.

The city population comprises 82.000. The share of elderly people here is higher than the average in Russia. 28.600 people (33 % of the total population) are on pension, among those 12.700 get special pensions for having worked in harmful or difficult conditions, 2.300 pensioners used to work at the Volga Chemical Plant.

2. Environmental pollution. One of the worst environment pollutants in Chapaevsk is the Volga Chemical plant. Before 1949 the plant produced combat poisonous gases: yperite, lewisite; from 1967 up to 1987 - hexachloran and its derivatives; nowadays it produces crop protection chemicals (liquid chlorine, acids, methylchloroform, vinilidenchloride, and some other chemicals). Chlorine presence in the chemical technological process determines a "bouquet" of organic and in-organic compounds in emissions and wastes, which is responsible for such super-toxic compounds as polychlorine benzo-n-dioxins and di-benzofurans. Emission of chlorine-containing compounds into the air is shown in table 1. Previously it was considered that hexachloran production was responsible for dioxins in the city environment. Tests seemed to confirm it. But after the production was closed in 1987, one can still observe "fresh" dioxins inflow. The study of the present day chemical plant technologies revealed that dioxins and similar compounds could be formed in the production of methyl chloroform, vinilidenchloride, dichlor propion acid, hexachlorethane, pentachlorfenolat Na and polychlorokamfen.

In 1994 the average concentration of dioxins in the air was 0,116 picogr/m³. The observations were carried out when the plant worked at 20 % capacity, so one can guess that previously dioxin air pollution had been higher. A great amount of dioxins is registered in the city soils, what's more important these are the soils of gardens and agricultural fields. Moving away from the plant one would see the dioxin content reduction — up to 36,8 nano gr/kg in downtown (2,7 km); to 3,9 nano gr/kg in the city southern part; to 0,9 nano gr/kg at the distance 10 – 15

km (table 1). Private house owners (18.000 in Chapaevsk) grow practically all vegetables and fruit for their own use in the gardens, thus getting an additional dioxin load.

According to Russian standards dioxin content in milk and dairy products should not be higher than 5,2 picogr/gr in fat calculation. The level is 5 – 10 times higher in the milk of the cows inside the city and out of it.

In 1995 city occupational pathologist had 51 workers of the chemical plant on the files, including 1 diagnosed with occupational bronchitis, 20 with occupational intoxication, and 30 with occupational acneform dermatitis (chloracne).

Table 1. Dioxin content in Chapayevsk soils and vegetables, 1992-94.

Distance to the plant	Dioxin content				
	Soils, nano gr/kg			Vegetables, picogr/kg	
	Minimum	Maximum	Average	Carrots	Potatoes
less than 2 km	40,4	298,0	141,3	0,07	0,021
2-7 km	8,9	71,2	36,8	0,78	2,0
7-10 km			3,9	0,12	0,005
Outside the city, 10-15 km	0,1	3,6	0,9	0,001	0,009

3. Quantity risk assessment. To assess the danger of dioxin impact on human health in Chapaevsk we used a mathematical model, directed at forecasting the certainty and degree of negative effects on humans in case of dioxin impact regarding the amount, continuation, way of exposure. The study of different ways of dioxin consumption displays the following:

If there are dioxins in the soil, and their level is from 0,18 to 160 nanogr/kg, a daily dose of their consumption with the soil, dust, aerosol particles while eating, breathing or through one's skin will be 0,2 – 2,9 picogr/kg of a person's weight. This dose is equal to a cancer risk of 1 – 6 additional cases per a million. The average daily consumption of milk and dairy products in human diet should be 1 liter (WHO recommendation for milk), a dose of daily dioxin consumption from milk could reach 91,5 % of the general consumption, while a general dose will be 20 picogr./kg/per day. This amount of daily dioxin dose throughout the life period could result in 40 extra cancer cases per a million. This daily dose for years (not less than 5) could 6 times heighten the risk of teratogeny effects development for a population.

In Chapaevsk chlorine production has been functioning for more than 60 years and practically all citizens have lived in the situation of constantly growing dioxin impact, and even when 7 years ago the main dioxin source was closed, the level of soil pollution (the time of 2,3,7,8-TCDD decay is 10-12 years) and consequently of agricultural crops grown here remain high. Thus, two models were introduced - for a 7-year and 30-year impact periods - to assess the consequences of dioxin impact. The basis for the models was diets for an "average" 7 year old child and an adult of 18-29. Available data on dioxin content in food products allowed to estimate a minimum and maximum dioxin amount consumed by children and adults. When consuming food containing maximum determined dioxin concentrations for 7 years both children and adults start displaying intoxication symptoms, that can be observed in their changed biochemical test results (coproporphyrins, coporphyrins and delta aminolevulin acid), lower reticulocits, 6 times higher risk of teratogeneous effects and additional cancer cases - 8 adult cases, 9,4 children cases per a million. Children also suffer porphyry, 1 degree and various skin irritations (chloracne, hyperpigmentation, and girsutism).

For both adults and children, consuming food with maximum dioxin concentration for 30 years results in a clinical picture of chronic TCDD intoxication supplemented with urino-porphiria, 2 – 3 degree, polyneurites, rapidly diminishing thymus mass (by 11 % for adults, 25 % for kids); additional cancer cases: 7,6 per 10.000 adults, 8,3 per 10.000 children.

4. Cancer morbidity. Component analysis showed the number of new cancer cases from 1984–86 to 1992–94 lowered insignificantly for men, mostly thanks to the changed morbidity risk, but grew by 11,8 % for women. The number of men with throat cancer and hemoblastoses rose significantly due to the higher morbidity risk. The number of women with hemoblastoses,

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uterus, breast and skin cancer lowered due to the changes in the age structure of the population, but the general number of cases increased thanks to a higher morbidity risk. So in general there is certain growth in the number of tumor cases. Fewer new cases of cervix cancer for women, stomach and lung cancer for both men and women took place mostly because of the lower morbidity risk. As compared to the other cities in Samara province the number of cancer cases (throat and lungs, digestive organs, bladder cancer, hemoblastoses) in Chapaevsk is maximum. In Chapaevsk the risk of getting cancer for males is 1.8 times greater than average in Russia, it is 1.5 times greater than in other cities of Samara province, for throat cancer those figures are 2,1 and 1,9-3,0 accordingly ($p>0.95$). Irrespective of the age, males in Chapaevsk get lung cancer 1,5-2,2 times more often than in general in Russia.

5. Cancer mortality. Annually 210 people die of malignant tumors in Chapaevsk, which is equal to 4 deaths a week. Cancer mortality comprises 17,5 % among other death reasons. Most probably, lower mortality rate in case of malignant tumors is connected with better early diagnostics and accordingly higher treatment efficiency.

Male cancer mortality in Chapaevsk is 1,2 times higher than an average figure for Samara province, 1,3 times higher than for Russia in general, 1,4 times higher than in the U.S. To assess Chapaevsk cancer death rate we chose corresponding province figures for control. In general male cancer mortality rate in Chapaevsk is higher in case of all malignant tumors: digestive organs, stomach, throat, lung, bones and tissue. The risk of dying from these forms of cancer for Chapaevsk men is 1,8; 3,3; 1,8; 3,5; 2,7; and 2,3 times higher than for the men in Samara province. Chapaevsk women have a higher risk to die of breast or cervix cancer. Cancer mortality reduces male average life expectancy by 2,3 years, women's — by 1,9 years. Lung cancer renders a maximum impact on average male life expectancy — 0,77 year, stomach cancer — 0,28 year, hemoblastoses — 0,17 year. Average women life span is 0,29 year shorter in case of stomach cancer, 0,27 year — breast cancer, 0,15 — lung cancer and 0,11 year — hemoblastoses.

Cancer-related deaths annually cost Chapaevsk more than 2,8 million person-years of life. Among them: lung cancer — 663.700, stomach cancer — 400.000, breast cancer — 187.000, hemoblastoses — 146.800 person-years. To compare Chapaevsk losses in person-years with average province data, standard age rates were calculated. Men losses (42.1) in Chapaevsk are twice as great as women losses (21.1). Lung cancer related deaths give the highest figures (14.2 for men, 1.7 for women), stomach cancer (5.3 and 3.2), hemoblastoses (2.1 and 1.5). Chapaevsk has twice as many digestive organs cancer related deaths (men and women) as average province figures. The same is true about stomach cancer (women), throat and lung cancer, malignant bone and soft tissue tumors (men).

Annual economic losses due to cancer mortality in Chapaevsk are 12 billion roubles (prices for the first half of 1995); 3,6 billion roubles refer to mortality because of respiratory organs' cancer.

Table 2. Changes in elements of life circle and its derivatives in case cancer mortality could be excluded, 1990 -1994 (Samara province, Chapaevsk)

Localization of malignant tumors	Men				Women			
	Deaths		Ratio (2):(3)		Deaths		Ratio (2):(3)	
	factual	expected	%	CI, 95%	factual	expected	%	CI, 95%
	2	3	4	5	6	7	8	9
Total	614	334,4	183,6	169,4-197,9	438	606,8	72,2	65,5-79,5
Including:								
intestine	23	6,9	332,5	210,8-498,7	11	13,4	81,9	50,9-146,6
stomach	87	49,7	175,1	140,3-215,7	73	95,7	76,2	59,7-96,0
colon	21	16,6	126,8	78,5-184,2	28	33,8	82,9	15,2-120,3
lung	228	83,1	274,5	239,7-312,8	41	147,9	27,7	19,0-37,6
breast	-	-	-	-	53	38,1	139,2	104,1-182,5
hemoblastoses	29	17,8	162,6	109,0-234,0	17	27,3	62,4	36,4-80,8

*) Standard death age rates in Samara province.

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The picture (with the exception of throat and lung cancer) to a great extent depends on the specialized medical assistance (timely diagnosing, adequate treatment, etc.) than on morbidity level.

6. Mortality from respiratory system diseases. From 1990 to 1994 in Chapaevsk respiration organs related mortality grew 1,6 times for male population (1990 — 123,8 per 100.000, 1994 — 201.600 per 100.000, standard for Russia). The most affected age group are men of 50 – 59 (2,4 times more cases) and 60 – 69 (1,9 times more cases). Mortality is considerably higher than in other cities of Samara province or in general in Russia. Mortality rates for both men and women have two peaks: at the age of up to 30 and 70 or older. For Chapaevsk men the risk to die of respiration organs related diseases is 2,5 times higher than in Samara province (table 3).

Table 3. Factual and expected mortality rate related to the number of respiration organs and cardiovascular diseases in Chapaevsk, 1990 - 1994

Cause	Gender	Deaths		Ratio (1) : (2)		Standardized rate	
		Factual	Expected Samara	%	CI, 95 %	per 100 000 of population	CI, 95 %
1	2	3	4	5	6	7	8
respiration organs	men	209	84,4	247,6	215,0 - 280,9	138,3	120,1 - 156,9
	women	117	159,2	73,5	60,8 - 89,2	41,1	34,0 - 49,8
cardiovascular	men	1504	951,4	158,1	150,2 - 165,2	1129,5	1073,1 - 1180,4
	women	2065	2231,5	92,5	88,5 - 95,9	661,2	632,4 - 685,4

^{*)} Standard – death age rates in Samara province.

In Chapaevsk morbidity and mortality levels constantly grow. Since 1984 to 1993 the number of chronic bronchitis cases or emphysema grew 1,6 times. The average morbidity rate (respiratory organs diseases) in Chapaevsk is higher than in other cities of the province — 1,3 times higher than in Zhigulyovsk and 2,2 times — than in Syzran.

7. Mortality from cardiovascular diseases. Within the last 5 years cardiovascular diseases were the cause of 67 % women deaths and 41-49 % men deaths, and the latter rate is growing from one year to another, particularly for men of 50 – 59 (2,4 times) and 30–39 (2,1 times). Women deaths in Chapaevsk related to cardiovascular diseases also grow. In Chapaevsk male mortality related to cardiovascular diseases is 1,23 times higher than in Tolyatti and 1,14 times higher than in Russia in general. The greatest differences are observed at the age of 30 – 49. The comparison of existing and expected (in accordance with Samara province mortality level) cardiovascular related deaths also displays a higher mortality rate in Chapaevsk (table 3).

8. Conclusion. Registered changes in various health indicators for both adults and children in the city of Chapaevsk are quite typical for places with harmful chlorine organic compounds impact. The employees of the chemical fertilizers plant that used to produce chlorine organic poisonous compounds and later plant protection chemicals and other products including chlorine often suffer from a specific professional disease: chlorakne; display higher adult mortality of lung, throat, digestive system cancer and other types of cancer. Mother's breast milk contains higher amount of dioxins.

Comparative analysis of human health risk from various dioxin sources revealed the main source - milk (and dairy products accordingly). Dioxin intake with food products comprises 90 % of the daily dioxin dose, but vegetable food products contribute a very insignificant share of the total intake. Consuming milk with high dioxin content may result in extra cases of malignant tumors 0,08 – 0,09 cases per 10.000 with a seven year exposure and 7,6 – 8,3 cases per 10.000 with a thirty year exposure. To improve the health of Chapaevsk population we would recommend developing and bringing into life a set of preventive programs, including prevention of malignant tumors; medical genetic consultations, monitoring breast milk for dioxins.