Dioxin Exposure around a Chemical Plant in Russia: Human Risk Assessment and Limit Concentrations Forecast

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At present in Russia there is a number of locations contaminated by dioxins and their congeners. It has resulted from emissions of chemical plants producing chlorophenols, 2,4,5-T, 2,4-D and others like that. We studied a situation in Chapaevsk where a serious contamination from a chemical plant takes place. Levels of dioxins and furans in soil in and around the town varied from 3 (more than 6 km away from the plant) to 300 (1.5 km away from the plant) ng TEF/kg. The dust from building walls contained up to 70 ng TEF/kg, and concentrations in the bottom sediment of a lake (12 km from the plant) were approximately 10 ng TEF/kg. (NATO/CCMS TCDD equivalents have been used).

In our opinion, the success in protecting human populations from dioxin exposure will depend on using a system analysis. To assess the risk of dioxin for human health and acceptable levels in the environment very detailed information and prospective forecasting algorithms are required. In our investigations we have used an integrated system for complex risk assessment of dioxin that has been developed by us and described in detail before[1-3] (Fig. 1).

The system represents a complex of mathematical models for the prediction of danger of dioxin exposure for humans and the environment. The system forecasts:

- dispersion of the pollutant from primary source/sources (model DECONT) and its behavior in abiotic parts of the environment (model SELENA);
- migration of the pollutant in food chains of ecosystems and bioconcentration in organs and tissues of plants, fishes, animals (model BIOLEV);
- safety concentrations of pollutants in the environment both in the case of isolated exposure (from one source by one or several pathways) and in the case of complex exposure (from several sources by several pathways simultaneously) for particular location (model LIMES);

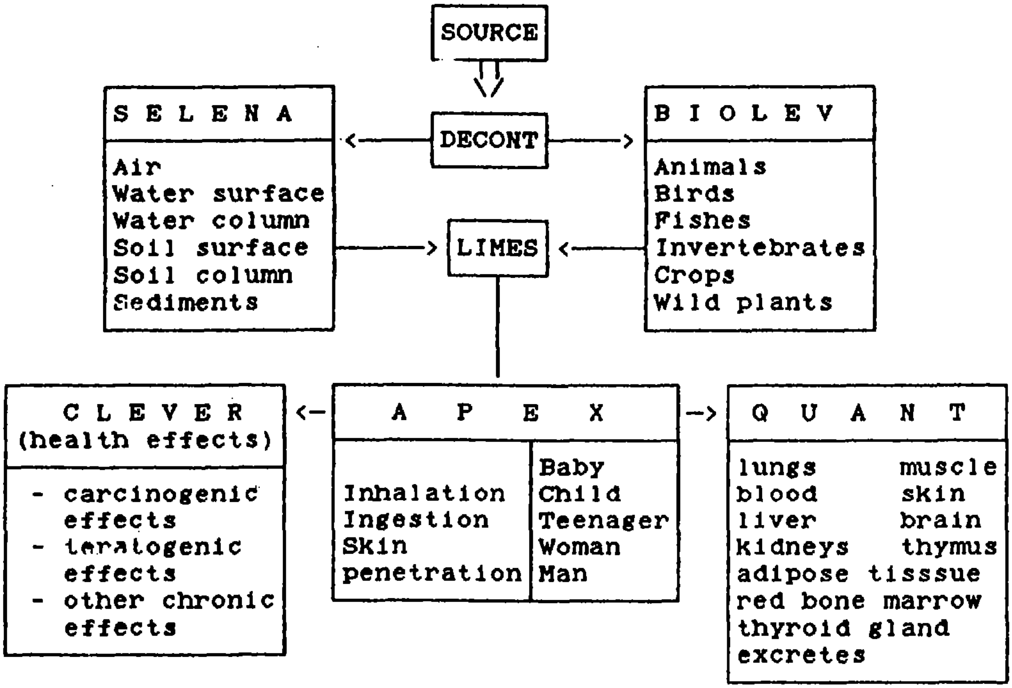

Fig. 1. The integrated system for complex risk assessment of 2,3,7,8-tetrachlorodibenzo-p-dioxin

- intake of the pollutant into the human body from different secondary sources and depots on different pathways (model APEX);
- toxicokinetics in the human body (model QUANT);
- human health effects caused by dioxin (model CLEVER).

RESULTS AND DISCUSSION

Calculations show that dioxin levels in samples of the urban soil correspond to human doses 0.5-2.6 pg/kg/day assuming that exposure is due to contaminated particles of dust and soil (inhaled or ingested). Carcinogenic risk level that corresponds to these doses is 1-5 cases per million.

However, dioxin levels in soil from the field (located 1.5 km away from the plant) where some root crops (potatoes, in the whole) and vegetables are growing can cause dioxin ingestion with food. So we should consider a complex intake of dioxin from the environment - from several sources (soil, dust, food, water from Chapaevka river) by several pathways (inhalation and ingestion) simultaneously. In this case carcinogenic risk connected to dioxin exposure can be very high - up to 270 cases per million.

Teratogenic risk does not exceed standard background values.

For the case when exposure occurs by multiple routes safety concentrations have been calculated:

Air (aerosols and dust particles), ng/cub. m	2.7×10^{-3}
Water, ng/l	7.0×10^{-3}
Farming soil, ng/kg	3.8×10^{-2}
Soil in residential area, ng/kg	2.9×10^{2}
Bottom sediments, ng/kg	1.1×10^{2}
Vegetables, ng/kg	3.7×10^{-2}
Potatoes and root crops, ng/kg	3.1×10^{-2}

Now we can demonstrate preliminary results only. A very high level of carcinogenic risk requires to be verified carefully. However, some relatively simple management decisions can already be realized. For example, exclusion of agricultural use of soil near the plant allows to decrease dioxin intake with food and to protect human health to a great extent.

As to a low level of teratogenic risk, the following must be considered. May be, we can assess combined exposure of dioxins but we can not assess combined effects of dioxin exposure. Algorithms for assessing exposure during some months of pregnancy are known but it is a great problem to determine how long-time exposure (for 20-25 years, starting from the birth) can affect women's pregnancy.

Undoubtly, detailed investigations of dioxins levels in the human body as well as data collecting about real health status in Chapaevsk are necessary. Also, additional information about dioxins levels in water and foods (especially, in cow's milk from suburbs of Chapaevsk) is required. It allows to correct our assessments and to select an optimal variant of environmental management alternatives.

REFERENCES

1 Zaikin SA. Methods of mathematical modelling in forecasting chemical catastrophes. - In: *Toxicological problems of chemical catastrophes*. Academy of Military Medicine, Sankt-Peterburg, 1991:42-43.

2 Zaikin SA, Gordov AM, Kazakova LI, Vlasova AD. Mathematical model for the assessment of limit concentrations of 2,3,7,8-tetrachlorodibenzo-para-dioxin in the environment. - In: *Dioxin'92*. Helsinki, National Institute for Occupational Health, 1992;10:385-389.

3 Zaikin SA, Gordov AM, Vlasova AD, Zykova TA. Mathematical algorythms for complex risk assessment of 2,3,7,8-tetrachlorodibenzo-para-dioxin. - In: *Dioxin'92*. Helsinki, National Institute for Occupational Health, 1992;10:389-392.