CHLORINATION OF DRINKING WATER: RISK FOR HEALTH

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Abstract

The carcinogenic activity of chlorination by-products' combinations at *per os* entering to the animal organisms in the different doses corresponded to their 1, 2, 5, 8, 20 maximal permissible concentrations for drinking water was investigated. The synergism of the combined chlorination by-products exposure consisted of the dose-related enhancing of the carcinogenesis and intensification of the toxic effect was established. Carcinogenesis of the combined chlorination by-products exposure was manifested in the tendency to the frequency magnification and reduction of the latent period of tumour development, toxic exposure of them was expressed in the destructive organs' damages. The additional risk of cancer development from the combined chlorination by-products exposure in a human was calculated.

Introduction

Chlorination of drinking water as a method of its disinfection is used in many countries of the world. Now days, in Ukraine chlorination is the main method of drinking water disinfection and the replacement it by other alternate methods is unreal in the near future.

Researches of the last years have shown that in disinfect in such a way drinking water chlorination by-products (CBP) are present, which forming exclusively owing to water chlorination in water stations [1-3].

The combined action of these substances can be different from their isolated influence to an organism. In the world literature such information is absent.

The purpose of the present work - experimental study of carcinogenic activity and risk evaluation of combined action of chloroform (CHLF), tetrachlorcarbon (TCHC), 1,2-dichlorethane (DCHE), threechlorethylene (TCHE) as collateral products of drinking water chlorination.

Methods

In work 520 mice F1 (CBAxC57BL6) both sex by 15-20 g mass were used. The animals were divided into 8 groups, switching on pure control
and solvent control (Table 1).

The researched substances were entered in an oil solution *per os* into stomach 5 times a week in equivalent dozes to their daily receipt in a human organism at the concentrations in water at a level 1-20 maximal permissible concentrations (MPC).

The substances were entered within 85 weeks. The animals were observed 4-5 weeks, then all of them were killed and are subjected to pathomorphological research.

Table 1. The scheme of experiment on study carcinogenic activity CBP by *per os* entering to mice F1 (CBAxC57 BL6)

Group	Amount of animals	Entered CBP	Single dose CBP /mouse		Total daily load CBP / mouse (mg/kg)	Concentration in water mg/l(MPC)
			mg	mg/kg		
I	70	CHLF	0.9	45.0	45,0	0.3 (5)
II	70	CHLF TCHC DCHE TCHE	0.9 0.036 0.12 0.36	45.0 1.8 6.0 18.0	70.8	0.3 (5) 0.012 (2) 0.04 (2) 0.12 (2)
III	70	CHLF	3,6	180.0	180.0	1.2 (20)
IY	70	CHLF TCHC DCHE TCHE	3,6 0.144 0.48 1.44	180.0 7.2 24.0 72.0	283.2	1.2 (20) 0.048 (8) 0.16 (8) 0.48 (8)
Y	60	solvent control	0.2ml	-	0.2ml	-
YI	60	pure control	-	-	-	-
YII	60	CHLF	0.18	9.0	9.0	0.06 (1)
YIII	60	CHLF	0.18	9.0		0.06 (1)
		TCHC	0.018	0.9		0.006 (1)
		DCHE	0.06	3.0		0.02 (1)
		TCHE	0.8	9.0	21.9	0.06 (1)

For histological study the lungs, kidneys, liver, spleen and other organs and tissue were taken if they had pathological alteration.

The evaluation of CBP action based on definition of average life expectancy of mice, frequency and average latent period of neoplasms development, their localization, multiplicity, histologic structure and malignancy.

The results of experiment were treated statistically with use well-known methods [4].

Account of risk of neoplasms development from an action of dozes which had not been investigated in experiment, was carried out with the help of multistage linearized model [4,5], which bases not only on modelling of probability events, but gives also statistical interpretation of a final total outcome of all processes and factors responsible for carcinogenic effect manifestation on a populations level.

Results

Results of pathomorphological researches have shown neoplasms development in mice of all groups, including control (table 2).

Table 2 - Results of experimental study of carcinogenic effect CBP by *per os* entering to mice F1 (CBAxC57Bl6)

Group	Sex	Amount of mice			Average time of neoplasms development (days)
		effective absol.	with neoplasms		
			malignant absol (%)	all absol (%)	
I	female	29	1 (3.4)	1 (3.4)	462±0
	male	27	0	1 (3.7)	577±0
II	female	28	1 (3.5)	3 (10.5)	530±29
	male	30	1 (3.3)	2 (6.6)	533±22
III	female	27	2 (7.4)	6 (22.2)	456±20
	male	25	2 (8.0)	6 (24.0)	436±12
IV	female	30	3 (10.0)	7 (23.3)	391±28
	male	25	1 (4.0)	2 (8.0)	435±0
V	female	26	1 (3.8)	1 (3.8)	555±0
	male	21	0	1 (4.7)	558±0
VI	female	28	1 (3.6)	1 (3.6)	605±0
	male	25	0	1 (4.0)	627±0
VII	female	28	0	1 (3.5)	560±0
	male	26	0	1 (3.8)	556±0
VIII	female	27	0	1 (3.7)	557±0
	male	25	0	1 (4.0)	554±0

It is necessary to underline, that by entering of CBP doses dependence and carcinogenesis activation by a doze magnification is marked.

So, under the action of CHLF in minimum doze 0.18 mg, which can come to organism at its concentration in water at a level 1 MPC (0.06 mg/l), carcinogenic effect is not revealed. The magnification of a CHLF doze up to 0.9 mg has caused carcinogenesis activation, which was exhibited in reduction of latent period of neoplasms development. The entering of CHLF maximum doze of 3.6 mg has caused statistically authentic ($p < 0.001$) growth of neoplasms frequency (up to 24.0 % of cases in male and 22.2 % - in female) on comparison with action of doze, which acts in an organism at CHLF concentration in water on the 1 MPC level. Under the combined entering of CHLF with other CBP the amplification of carcinogenic effect is marked.

Carcinogenesis under the action of large dozes of a complex (8-20 MPC) was exhibited in authentic ($p < 0.001$) increase of frequency and decrease of average latent period of neoplasms development on comparison with isolated action of CHLF, tendency to increase of neoplasms malignancy. Under the action of complex at level of lower dozes (2-5 MPC) is marked the tendency to increase of frequency and reduction of latent period of neoplasms development on comparison with effect of separate entering of CHLF in the same doze.

Discussion

The features of carcinogenesis, revealed by us, give the basis to think about existence of potential danger of increase populations oncologic disease, which uses chlorinated drinking water polluted by a complex CBP. It is confirmed also by results of account of risk of neoplasms development (table 3 and 4).

Table 3. - Populations risk of neoplasms development under the action of various CHLF dozes

Concentration of CHLF in water		Risk of neoplasms development	
In magnitudes MPC	mg/l	for life	for one year
20	1.2	$2.8 * 10^{-3}$	$3.9 * 10^{-5}$
15	0.9	$2.1 * 10^{-3}$	$3.0 * 10^{-5}$
10	0.6	$1.4 * 10^{-3}$	$2.0 * 10^{-5}$
5	0.3	$6.9 * 10^{-4}$	$9.9 * 10^{-6}$
4	0.24	$5.5 * 10^{-4}$	$7.9 * 10^{-6}$
3	0.18	$4.1 * 10^{-4}$	$5.9 * 10^{-6}$
2	0.12	$2.8 * 10^{-4}$	$3.9 * 10^{-6}$
1	0.06	$1.4 * 10^{-4}$	$1.9 * 10^{-6}$

As it is shown in the table 3, populations risk of neoplasms development under the action of CHLF in doze appropriate concentration in water 1MPC (0.06 mg/l), makes 1.9 cases on 1 million population per one year, that corresponds to range of the international standards.

Table 4 - Populations risk of neoplasms development under the action of combined action of CBP depending on doze

Substances, concentrations in water in magnitudes MPC, (mg/l)	Risk of neoplasms development	
CHLF + TCHC, DCHE, TCHE MPC, (mg/l)	for life	for one year
1 (0.06) + 1 (0.006; 0.02; 0.06)	$1.5*10^{-4}$	$2.1*10^{-6}$
5 (0.3) + 2 (0.012; 0.04; 0.12)	$2.6*10^{-4}$	$3.7*10^{-5}$
10 (0.6) + 4 (0.024; 0.08; 0.24)	$5.6*10^{-4}$	$8.0*10^{-5}$
15 (0.9) + 6 (0.036; 0.12; 0.36)	$7.4*10^{-4}$	$1.1*10^{-4}$
20 (1.2) + 8 (0.048; 0.16; 0.48)	$10.8*10^{-4}$	$1.5*10^{-4}$

The increase of CHLF doze leads to magnification of risk. Under the action of substance in doze equivalent to water contamination at level 5 MPC (0.3 mg/l) risk makes 9.9 cases, at level 10 MPC (0.6 mg/l) - 20 cases on 1 million population per one year.
Combined action CBP stipulates even more significant risk (tab. 4). So, populations risk of neoplasms development under the action of CBP combination in dozes appropriate to water contamination at level 1 MPC (CHLF 0,06 mg/l, TCHC 0,006 mg/l, DCHE 0,02 mg/l, TCHE 0,06 mg/l) will increase insignificantly (at 1,1time), whereas under the action of CHLF in concentration at level 5 MPC in combination with other CBP at level 2 MPC will increase more than in 3 times on comparison with isolated action of CHLF in the same dozes and makes accordingly 2.1 and 37.0 cases on 1 million population per one year.

Conclusions

Thus, our researches have shown reliability of magnitude CHLF MPC (0.06 mg/l), which acts also in Ukraine, and the danger of magnification of populations risk of neoplasms development under condition of water contamination by concentrations higher than MPC, and especially in combinations with other CBP.

It stipulates necessity of the mandatory account of features of combined action CBP on an organism and their joint presence at drinking water in practice of hygienic normalization and sanitarian monitoring of water.

References

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