RELATIVE BIOLOGICAL EFFECTIVENESS OF RADIOACTIVE AND CHEMICAL HARMFUL SUBSTANCES

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Summary

In experiments on mice, rats and water living beings it has been established that the range between threshold and maximum permissible concentrations for radionuclides is 100 times and more as for chemicals.

Under present circumstances when there is almost equal possibility from economic point of view to produce energy by utilization of chemical or nuclear fuel, the problem of relative danger of chemical and radioactive wastes for man and biosphere has key significance. The separate available data and, in particular, conclusions made by Jammet, Bellin et al /1/ allowed to suppose that the relation of acute lethal intake ($LI_{50/30}$) to daily intake (DI) at the limits for population for chemicals is 100-1000 times less than for radioactive substances. The data from our review /2/ on relative danger of chemical substances with known $LI_{50/30}$ for human organism on the one hand and of radionuclides on the other hand are shown in Table I.

Table I shows that the contemporary limits on intake for population in case of radionuclides are 3-6 orders more safe than in case of chemicals according to the acute lethal index.

The ratios of danger according to many other indices were examined by us in chronic experiments on mice and rats. During all life the animals (50 pieces per one substance and each concentration) consumed drink water contaminated with separate radionuclides or chemicals from 1 to 10^6 of maximum permissible concentrations (MPC) for population. Among the investigated substances there were radionuclides: ^{60}Co ($1,2 \times 10^{-8}$), ^{65}Zn ($1,0 \times 10^{-8}$), ^{90}Sr ($1,3 \times 10^{-10}$), ^{137}Cs ($1,5 \times 10^{-9}$), ^{203}Hg ($6,0 \times 10^{-9}$), ^{210}Pb ($4,0 \times 10^{-11}$), ^{210}Po ($2,4 \times 10^{-11}$), ^{226}Ra ($4,0 \times 10^{-11}$) and chemicals: methyl mercury (0,0001), sublimate (0,005), nitrate lead (0,1), strontium (2,0), beryllium (0,0002), hexamethylendiamin (0,01), chlorophoss (0,05). Their MPC's are put in brackets (for radionuclides in Ci and for chemicals in mg per litre of water).

The so-called "threshold concentrations" (TC) for a given number of animals were determined with respect to 14 indices (see Table 2). The obtained results are given as common logarithms for the ratios of TC to MPC.

The range between MPC and TC for radionuclides was found to be average 100 times as much as for chemicals. The sensitivity of all tests used may be considered identical. Only the "atypical cells" and "autoallergy" showed a little higher sensitivity.

The lesser danger of radioactive contamination is particularly evident for water living beings. This has been shown in our experiments when those beings were kept in aquariums contaminated separately by the above radionuclides and chemicals.

The approbated tests and common logarithms of the ratios between MPC and TC are presented in Table 3.

The concentrations of radionuclides 100,000 times higher than MPC turned out to be ineffective for the most of water living beings with the exception of tadpoles. The exception needs a repeated verification. As for chemicals it was enough, as a rule, to keep the concentration on MPC-level or 10 times of MPC for discovering their effects. Death-rate of Daphnia magna from chlorophoss increased even below concentration of 0.01 MPC.

Our data confirm the known conclusion, that progress of nuclear energetics leading to decreasing of chemical contamination of the environment is one of the best prophylactic measure from the hygienic point of view.

References

1. Jammet H., Bellin A., Lacourly G., Beau M., Morbat M. Choix de sites de centrales nucleaires et protection de l'environnment. In: Siting of Nuclear Facilities. IAEA, Vienna, (1975), pp. 335-347.

2. Ramzaev P.V., Tarasov S.I. Problem of hygienic estimation of simultaneous intake for different in nature harmful agents. In: Hygienic estimation of radiation and non-radiation factors. Leningrad, (1976), pp. 5-10.

Table I. Comparative danger of chemical and radioactive substances after ingestion

Substance	$LI_{50/30}$ of single intake	DI	Ratio of $LI_{50/30}$ to DI
I. Chemicals:			
Cyanide of Na,K..	0.12 g	0.2 mg	6.0×10^{2}
Arsenic (As^{3+})	0.12 g	0.1 mg	1.2×10^{3}
Stibium	1.00 g	0.1 mg	1.0×10^{4}
Insecticide DDT	6.00 g	0.2 mg	3.0×10^{4}
Mercury (sublimate)	0.50 g	0.01 mg	5.0×10^{4}
II. Radionuclides:			
^{137}Cs	210 mCi	3.3×10^{-9} Ci	6.4×10^{7}
^{3}H	70 Ci	7.0×10^{-7} Ci	1.0×10^{8}
^{90}Sr	70 mCi	2.6×10^{-10} Ci	2.6×10^{8}
^{226}Ra	35 mCi	0.79×10^{-10} Ci	4.3×10^{8}

Table 2. Common logarithms for ratios of the threshold concentration to maximum permissible concentration of radionuclides and chemicals

Biological test	log of ratios for radionuclides	log of ratios for chemicals
Life time	4.8	3.0
Function of nervous system (threshold of sensitivity)	4.1	2.2
Physical endurance (running)	5.0	2.5
Function of reproduction:		
- menstrual cycle	4.7	2.1
- ability for pregnancy	5.0	2.7
- number of new-borns	5.1	2.7
- survival of offsprings	5.8	3.0
Immunologic reactivity:		
- nonspecific immunity	4.4	2.7
- autoallergy	3.7	1.9
Blood test		
- erythrocytes	5.2	2.3
- leucocytes	4.5	2.9
- lymphocytes	4.1	2.8
- neutrophils	4.7	3.0
- atypical cells	3.7	2.5
Average	4.6 ± 0.2	2.6 ± 0.1

Table 3. Estimation of danger to some water living beings from radioactive and chemical substances

Biological test and species	log of ThC/MPC for radio-nuclides	log of ThC/MPC for chemicals (range)
Death-rate of spawn (Coregonus peled Gemelin)	⩾ 5	2 - 0
Larvae abnormalities (Coregonus peled Gemelin)	5	3 - 0
Acceleration of hatching (Coregonus peled Gemelin)	>5	2 - 0
Death-rate of tadpoles (Rana temporalae)	>5 - 3	3 - 1
Death-rate of snails (Fissa)	>5	2 - 1
Death-rate of (Daphnia magna)	>5	3 - (- 2)
Death-rate of infusorians (Paramecium caudatum)	>5	4 - 1
Inhibition of microflora (saprophytic)	>5	4 - 1
Inhibition of biochemical consumption of oxygen	>5	4 - 1