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HARMONIZATION OF TOXICOLOGICAL AND SANITARY HAZARD ASSESSMENT OF DEMOLITION WASTES OF A FORMER CHEMICAL WEAPONS PRODUCTION FACILITY

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Goal of Research

- Development of toxicological procedures and criteria for hazard assessment of building wastes potentially contaminated with toxic compounds for formulating unified principles for hazardous waste regulation

- In Russia hazard assessment of industrial wastes is based on the methodology for sanitary regulation of environmental chemical pollution
- Regulatory document «Sanitary Rules for Assessment of Hazard Class of Toxic Production and Consumption Wastes (Sanitary Norms and Rules 2.1.7.1386-03)»

- Complex chemical and toxicological research on the assessment of hazard class of demolition wastes from a former chemical weapons production facility established that :

  Criteria for hazard assessment of general industrial wastes are not fully adequate for hazard class assessment of wastes from facilities for production of or operation with highly toxic chemicals (TC)

General Scheme of Waste Hazard Assessment

Biochemical screening to select the most
ntaminated samples

Survey GC-MS analysis

Waste hazard calculation

Modeling release of toxic component into contact media (air, water) and determination of water leaching and air emission indices

Integral toxicity assessment by biotesting

Assessment of waste impact on soil and vegetation

Animal toxicity testing

Hazard class assessment of wastes, based on the results of integrated experimental assessment of their toxicity and hazard

Key Blocks in Demolition Waste Hazard Assessment

- Identification analysis (direct physicochemical and biochemical analysis)
- Modeling release of toxic chemicals into contact media mimicking environmental objects (water, air)

Results of Survey Analysis of Organic Compounds in Demolition Wastes

Compound name	Concentration, mg/kg
2,6-Diisobutyl-4-methylphenol	≤45,98
Bis(diethylamino) disulfide	≤ 97,9
Butanethiol	≤7600
Butylamine	≤87,6
Dibutyl disulfide	≤1916
Dibutyl phthalate	≤4232,0
Diidocyanide	≤106,5
Docosane	≤270,2
Isobutyl methylphosphonate	≤247,7
Xylene isomers	≤991,5
Methylphosphonic acid	≤539,0
n-Butanol	≤1669,0
O,O-Diisobutyl *S*-3-(isobutylsulfanyl propyl) phosphorothioate	≤ 84,1
O,O-Diisobutyl *S*-isobutyl phosphorothioate	≤1226
Octadecanoic acid	≤281,5
Sulfuric acid	≤2154,43
Phosphorothioic acid	≤106,0
Toluene	≤452,8
Hydrogen trisulfide	≤43,8
Fyrol	≤30,7
Phosphoric acid	≤306,0
Phthalic acid	≤2291,2
Phthalic anhydride	≤1398
Ethylbenzene	≤96,2
Ethylene glycol	≤70,1

Components Contributing Most in the Calculated Waste Hazard

Waste material	Components contributing most in the total waste hazard (*K*i)	Hazard coefficient (K_{Σ})
Paint-and-lacquer (wall and sealing coatings)	*n*-Butanol (*K*i = 3,8); fyrol (*K*i = 2,97); xylene isomers (Ki = 1,86)	13,1
Cable-conductor	Alkanes (Ki = 0,94); fyrol (Ki = 0,30); tributyl phosphate (Ki = 0,23)	1,7
Waterproofing	Alkanes (Ki = 1,7), dibutyl phthalate (Ki = 1,5); toluene (Ki = 0,9)	4,5
Paint-and-lacquer metal coatings	Hexachlorobiphenyls (Ki = 801,57); Pentachlorobiphenyls (Ki = 419,56); Dichlorobiphenyls (Ki = 103,2)	1562,1
Heat insulating (glass fiber and glass cloth)	Dibutyl sebacinate (Ki = 4,4); p-octyl isocyanate (Ki = 4,5);	20,3
Heat insulating (asbestos)	Ethyl acetate (Ki = 0,17); octanal (Ki = 0,04); nonanal (Ki = 0,04)	0,52
Ceramic (Raschig rings)	Total alkanes (Ki = 0,72);	1,38
Rubber-fabric	2-Benzothiazole (Ki = 0,12);	1,09

Criteria for Hazard Class Assessment of Wastes Contaminated with Highly Toxic Organophosphorus Chemicals

For destructive materials (concrete, lime, plaster), criteria in the «Sanitary and Epidemiological Requirements to Soil Quality»* were used

Higher then MPC	Soil contamination category (SanPiN 2.1.7.1287-03 # 4500 05.05.03)	Proposed interpretation of waste hazard class
Background to MPC	Clean	Low hazard (Class 4)
1-2 MPC	Permissible	Moderate hazard (Class 3)
2-5 MPC	Hazardous	High hazard (Class 2)
>5 MPC	Extremely hazardous	Extreme hazard (Class 1)

*Sanitary and Epidemiological Requirements to Soil Quality. SanPin 2.1.7.1287-03 No. 4500 05.05.03. Moscow, 2004.

Demolition Wastes Hazard Assessment by the Criterion of Complex Choline Esterase Inhibition Activity by the Results of Biochemical Testing

Waste Material	Relative choline esterase inhibition activity*(rel. units)	Hazard class
Paint-and-lacquer (wall and sealing coatings)	2,7	2
Cable-conductor	2	3
Waterproofing	2	3
Paint-and-lacquer metal coatings	5	1
Heat insulating (glass fiber and glass cloth)	< 1	4
Heat insulating (asbestos)	< 1	4
Ceramic (Raschig rings)	3,2	2
Rubber-fabric	< 1	4

•On the basis of the exceeding degree of MAC for VX in soil

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Organic Compounds Released into Contact Media from Demolition Wastes

Air

Toxic chemical	Concentration, mg/kg
Acetophenone	≤215,6
Buthanethiol	≤760,0
Butyl acetate	≤499,5
Hexacosane	≤222,6
Heptacosane	≤165,8
Docosane	≤270,2
Isobutanol	≤37,2
Xylene isomers	≤305,5
n-Butanol	≤1669,0
Toluene	≤574,7
Tridecane	≤96,8
Tricosane	≤290,8
Undecane	≤30,6
Ethylbenzene	≤191,1

Water

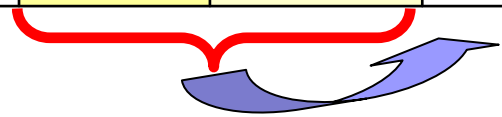
Toxic chemical	Concentration, mg/kg
Phthalic acid	≤784,3
Butanol	≤1668,0
Hexadecanoic acid	≤1419,3
Dibutyl pthalalte	≤4232,0
Xylene isomers	≤10400,0
Toluene	≤574,7
Phthalic anhydride	≤1398,0
Oxalic acid	≤199,9
Ethylbenzene	≤191,1
Ethylene glycol	≤308,1
Acetophenone	≤215,0
Bis(diethylaminoethyl) disulfide	≤97,9
Butanethiol	≤7600,0
Dibutyl disulfide	≤1916,0
Dibutyl sulfide	≤107,7
Dicresyl phosphate	≤45,4
Methylphosphonic acid	≤539,0
O,O-diisobutyl *S*-3-(isobutylsulfanylpropyl) phosphorothioate	≤84,1
O,O-diisobutyl *S*-isobutyl hosphorothioate	≤1226,0
Phosphoric acid	≤106,0

Tentative Water Leaching (TWLI) and Air Emission Indices (TAEI) Indices for Demolition Waste Samples from «Durty» Areas

Waste material	TWLI	Hazard Class	TAEI	Hazard Class
Paint-and-lacquer (wall and sealing coatings)	73,63	3	14,27	2
Cable-conductor	48,62	3	1,32	3
Waterproofing	20,84	3	0,47	4
Paint-and-lacquer metal coatings	8,1	4	>0,001	4
Heat insulating (glass fiber and glass cloth)	32,21	3	0,25	4
Heat insulating (asbestos)	9,76	4	3,6	4
Ceramic (Raschig rings)	16,48	3	2,5	4
Rubber-fabric	5,13	4	5	3

Results of Experimental Hazard Assessment of Demolition Wastes from a Former Chemical Weapons Production Facility (on the basis of «Sanitary Regulations on Hazard Class Assessment of Toxic Production and Consumption Wastes. SanPin 2.1.71386-03»)

Wastes	Calculat-ion based on survey GC-MS analysis	Releaseinto contact media		Impact on Soil and Vegetation System			Extract dilution, effective			Integral hazard
		TWLI/ hazard class	TAEI/ hazard class	Microorganism inhibition (%)/ hazard class	Soil redox potential (mV)	(ER_{50}) / hazard class	On hydro-bionts	DL_{50}/ hazard class	Subacute experiment/ hazard class	
	Building wastes from «durty» areas									
Paint-and-lacquer materials	2	73,6/3	14,3/2	52/3	25/4	1,3/3	10 / 4	ND / 4	**<10 / 4**	**2**
Waterproofing materials	3	30,3/3	5,7/3	28,5/4	15/4		1 / 4	ND / 4	**<10 / 4**	**3**
Cable materials	3	48,6/3	1,32/3	61/3	10/4		10 / 4	ND / 4	**<10 / 4**	**3**
Metal materials	1	>1000/1	4					ND / 4		**1**
Glass materials	4	32,2/3	0/4	35/4		4,45/3	1/4	13700/4	**10/4**	**3**
Asbestos	4	9,76/4	0/4	4/4	10/4	4,46/3	1 / 4	ND / 4	**<10 / 4**	**3**
Raschig rings	2	16,48/3	1,4/4	8/4	10/4	0,25/4	1 / 4	ND / 4	**<10 / 4**	**2**
Rubber-fabric materials	4	5,13/4	5/4	16/4	12/4	2,03/3	1 / 4	ND / 4	**<10 / 4**	**3**



Biochemical Parameters of Rat Blood After Exposure to Powdered Building Wastes (5 times a Week for 1 month)

Rat group	AChE (erythr.) mM/l min ·	ChE (plasma) mM/l min ·	AST, МЕ/л	ALT, mU/l	AP, mU/l
Control	1,64 ±0,05	0,46 ±0,02	223,40 ±13,97	77,48 ±13,12	97,63 ±5,68
Experiment 1 (moist skin)	1,62 ±0,05	0,67** ±0,03	264,60 ±19,52	55,30 ±2,09	70,50** ±5,16
Experiment 2 (moist skin)	1,64 ±0,07	0,59* ±0,04	273,9* ±12,96	64,43 ±3,37	103,20 ±11,58
Experiment 3 (moist skin)	1,81 0,11±	0,85** ±0,09	245,90 ±19,42	53,24* ±2,67	80,36 ±10,67
Experiment 4 (moist skin)	1,97 ±0,11	0,93** ±0,10	216,80 ±14,40	53,63* ±3,20	60,87** ±7,98

* - < 0,05; ** – p < 0,01; #– p < 0,1

Biochemical Parameters of Rat Blood 1 Month After Exposure to 100% Aqueous and Oil Extracts of Building Wastes in Subacute Experiment

Rat group	AChE (erythr.) mM/l min ·	ChE (plasma) mM/l min ·	AST, ME/л	ALT, mU/l	AP, mU/l
Control	1,64 ±0,05	0,46 ±0,02	223,40 ±13,97	77,48 ±13,12	97,63 ±5,68
Experiment 1 (moist skin)	1,62 ±0,05	0,67** ±0,03	264,60 ±19,52	55,30 ±2,09	70,50** ±5,16
Experiment 2 (moist skin)	1,64 ±0,07	0,59* ±0,04	273,9* ±12,96	64,43 ±3,37	103,20 ±11,58
Experiment 3 (moist skin)	1,81 0,11±	0,85** ±0,09	245,90 ±19,42	53,24* ±2,67	80,36 ±10,67
Experiment 4 (moist skin)	1,97 ±0,11	0,93** ±0,10	216,80 ±14,40	53,63* ±3,20	60,87** ±7,98

Behavioral Reactions in Rats after 4-week Cutaneous Applications of Waste Extracts (3-min observation for each parameter)

Wastes	Crossed sectors	Vertical stands	Hole explorations	Washings	Total motor activity
Control	33,7±3,6	10,2±2,3	8,2±1,9	2,8±0,7	54,8±3,74
Glass materials	20,0**±0,9	7,3±1,0	7,2±1,6	2,3±0, 7	36,8**±2,6
Asbestos	28,3±8,3	5,7±2,2	5,5#±1,1	2,3±1,1	41,5±9,8
Rubber-fabric materials	26,8±5,88	6,3#±1,26	6,5±1,65	1,5±0,72	41,2±8,06

* - < 0,05; ** – p < 0,01; #– p < 0,1

Hazard Assessment on Intraperitoneal Exposure (after K.K. Sidorov)

- **Animal death rates on introduction of 100% waste extracts in highest possible doses suggest a moderate waste hazard (Hazard Class 3)**

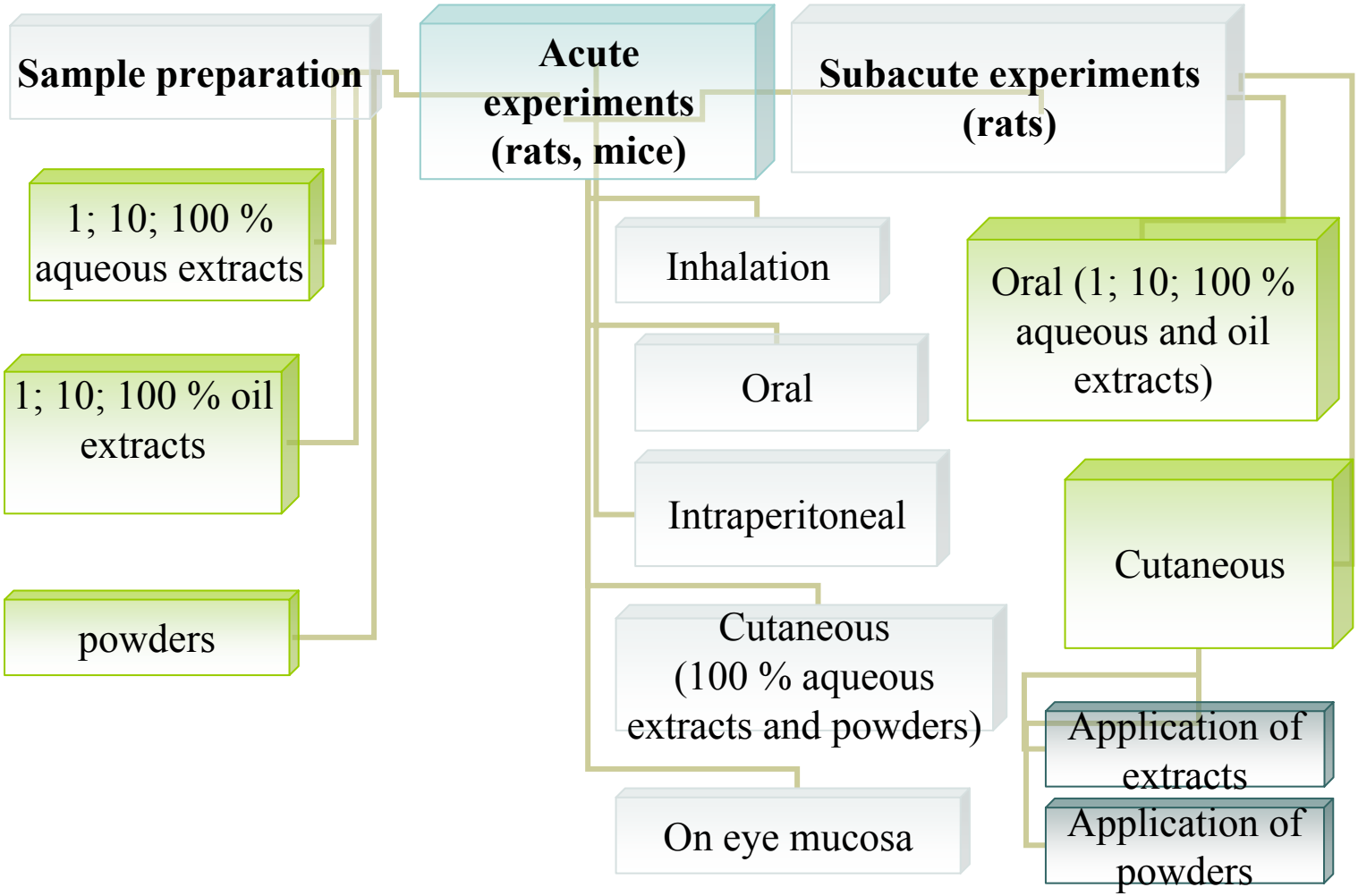
Additional Toxicity Testing Procedures for Hazard Assessment of Wastes Potentially Contaminated with Toxic Chemicals

- Acute intraperitoneal exposure experiments
- Subacute cutaneous application experiments

Suggested Criteria for Waste Hazard Assessment in Subacute Experiments:

- **Effective undiluted waste extracts: Moderate hazard (Hazard Class 3);**
- **Effective 1:10 diluted waste extracts: High hazard (Hazard Class 2);**
- **Effective 1:100 diluted waste extracts: Extreme hazard (Hazard Class 1).**

General Scheme of Experimental Toxicity Testing of Wastes



I sincerely appreciate your attention !

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