Toxicological and Sanitary Assessment of Hazardous Wastes and Materials Exposed to Toxic Chemical Compounds

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- **DURING DISMANTLEMENT AND CLOSING DOWN OF PRODUCTION FACILITES, WHICH IN THE PAST WERE IN CONTACT WITH CWA OR WERE USING TOXIC CHEMICAL AGENTS, THE BUILDING STRUCTURES TO BE DEMOLSIHED ARE REGARDED AS POTENTIAL WASTES**

- **THE FUTURE OF THE WASTES (RECYCLING, STORAGE, DISPOSAL, DESTRUCTION) WILL DEPEND ON THE LEVEL OF THEIR POTENTIAL HAZARD FOR HUMAN AND ENVIRONMENT**

Main Aspects of the Problem

- Long time that has passed since the direct contact of toxic chemical agents and the material
- Limited information in the available literature on the behavior of toxic chemical agents in different materials over long time
- As a rule, presence of small amounts of toxic chemical agents or absence thereof, breakdown products prevailing
- A priori unpredictable chemical composition of wastes and materials exposed to the influence of toxic chemical agents, various process and auxiliary reagents, decontaminants over long time
- Wide range of products produced by CWA interaction with matrix components and reagents, usually not described in toxicity terms
- Lack of information on qualitative and quantitative composition of both micro- and macro components
- Lack of methodology for coordinated chemical-analytical and toxicological analysis

Main Mistake

- The task of identifying the chemical compounds determining toxicity may remain unresolved

- **Diversity of materials**, which should be regarded as wastes contaminated with toxic chemical agents:

- concrete, brick (silicate, clay)
- moisture barrier of slabs
- heat insulation (fiberglass, mineral fiber, asbestos)
- steel with and without paint and lacquer coating, corroded (process equipment and vessels;
- pipelines, elements of structures and ventilation systems)
- electric cables in insulating sheaths of power supply, control, communication and alarm systems, etc.
- textile and rubber-textile items (personal protective equipment, fire hoses, etc.)
- activated charcoal
- ceramics (packing of columns and scrubbers)

- ***Solution***

develop sampling methodology and map to cover all types of materials

- **Lack or Absence of Information**

- on manufacturing conditions
- faults in process
- emergency and contingency situations
- composition of decontaminants used
- frequency of decontamination

- ***Solution***

interview former employees of the facility and officials of supervisory bodies, analyze archived records of supervisory bodies, perform hygienic evaluation of the technological process to cover all weak points

- **Evidence of contact between toxic chemical agent and material**

- ***Solution***

Search for degradation products (with the view to autocatalysis, hydrolysis, thermal, biological degradation, photodegradation and resynthesis)

- **Complexity of physicochemical analysis**
  - **heterogeneous composition of wastes**
  - **heterogeneous composition of physicochemical properties of various types of matrices affecting degradation of toxic chemical agent**
- **Problem related to analysis of microquantities of highly toxic compounds against matrix macrocomponents**
- **Difficulties related to toxic chemical agent analysis in complex matrices to prove the presence of a toxic chemical agent**

Solution:

- ***classify matrices by influence on toxic chemical agents in the environment (indifferent, degradation inhibitive, degradation accelerative)***
- ***determine field conditions affecting the behavior of toxic chemical agents (humidity, pH, t°, solar irradiation and other types irradiation)***
- ***use supercritical fluid extraction***
- ***use "Protocol for «Protocol for Toxicity Identification and Evaluation» (EPA Method 1311)***
- ***use OPCW recommended procedures***
- ***develop direct GC-MS procedure***

- Nonspecific inhibition of ACE when toxic chemical agents are analyzed by biochemical method by degradation products of the toxic chemical agent and other organic compounds

- ***Solution:***
  - ***check ACE inhibition selectivity***
  - ***elimination of unwanted admixtures by: directed fractionation of sample***

Solution

- Impossibility to identify signs of intoxication typical for each group of toxic chemical agents

- ***carry out chronic experiments with the view to the toxic chemical agent capabilities to migrate to the environment and in case of skin contact***
- ***assess matrix (material) hazard by nonspecific signs of intoxication subject to proven presence of a toxic chemical agents or degradation products thereof by direct methods***
- ***biotesting in vitro using modern markers and methods to include proteomics and genomics and other methods to unambiguously establish the fact of influence***

Computational Method Applications:

The method enables to obtain:

- **Calculated values of hazard class of the construction waste at the former facilities which used highly and extremely hazardous chemical compounds in their operations**
- **Rapid assessment of chemical hazard of the construction structures (buildings and structures) contaminated in any emergency situation or chemical terrorism**
- **Ranking of building/structure “contamination” for introducing a selective approach to the process of dismantling, transportation, and stockpiling (disposal) of waste**

- **Hazard class of the agent-containing waste should be defined taking into consideration the actually determined agent stability in specific chemical matrix and the residual quantities of these supertoxicants in waste**

Calculation (SR 2.1.7.1386-03)

- **Ki = Ci/Wi (1)**
- **lg Wi = 1,2 (Xi - 1), (2)**

  where: Ci – concentration of i-component in the waste (mg/kg);
  Wi – hazard factor of i-component in the waste;
  Xi – averaged hazard parameter of i –component in the waste;

- **The total hazard index K is equal to the sum of Ki of all waste components:**

  $K = K_1 + K_2 + K_3 + \ldots K_i$ (3).

Assessment of chemical soil contamination with organic compounds belonging to Hazard Class 1.

– (Citation for the Sanitary and Epidemiological requirements to the Soil Quality, Appendix 1)

Higher than MPC	Soil contamination category (SanPiN 2.1.7.1287-03 #4500 05.05.03)	Proposed interpretation of waste hazard class
Background – 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)

Solution

- **Absence of regulatory documents governing hazard class identification for wastes containing such highly toxic compounds as CWA**

- ***develop methodical approach to and regulatory documents for assigning hazard class to wastes containing supertoxicants***
- ***develop criteria to evaluate quality and integrity of integrated toxicological and hygienic expert review results***
- ***develop methodology for***

Conclusions

- Solution of the problem must be based upon reliable data of direct physicochemical analysis of toxic chemical agent and potentially toxic products of its transformation in wastes and materials as well as in coupling media simulating the environment versus existing hygienic standards in the environment protection.
- Hazard class must be assigned depending on the extent, to which it exceeds MPC in the soil.
- Integrated toxicological and hygienic tests must be carried out to protect the problem solution from bad errors possible in course of physicochemical analysis and to evaluate as a whole the consequences arising from the effect of the set of compounds contained in the waste or material without identifying specific manifestation typical for the toxic chemical agent.

Recommendations

- **In order to generalize the lessons learnt from such works, standard operating procedures (SOP) should be developed for each stage of the studies**

General Outline of Toxicological and Hygienic Experiment

Biochemical screening in vitro

Chemical analysis based on unknown compound sampling principle

Assigning waste hazard class by estimation

Determination of water migration and air migration indices.

Biologic testing to include hydrobiological unit

Study of waste impact on soil and vegetation

Determination of acute and subacute toxicity using mammals

Substantiation of waste hazard class using the results of integrated experimental assessment of their toxicity and hazard

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I sincerely appreciate your attention !