PRINCIPLES OF GEOLOGICAL SUBSTANTIATION FOR TOXIC WASTE DISPOSAL FACILITIES SITES SELECTION

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ABSTRACT

Industrial, domestic and military activities result in accumulation of toxic and hazardous waste. Disposal of these waste comprises two main approaches: technological processing (utilization and destruction) and landfill. According to concepts and programs of advanced countries technological solutions are preferable, but in fact over 70 % of waste are buried in storages, prevailingly of nearsurface type. The target of this paper is to present principles of geological substantiation of sites selection for toxic and hazardous waste isolation facilities location.

Key words: toxic waste, hazardous waste, storrage, site selection, geological parameters

Isolation of toxic and hazardous waste, i.e. disposition in storages, comprises two principles: long term storage and (final) burial. A storage of any type is complex multybarrier system comprising engineered and natural (i.e. geological medium) barriers.
In practice there exist two types of storages: nearsurface and underground. These types differ in the role of engineered and natural subsystems: nearsurface storages are geological-engineered systems, underground ones - engineered- geological systems.
In countries of Europe and USA the use of nearsurface storages is in practice. Underground storages there exist in Germany (reworked salt mines) and Sweden (in granite mines), specific examples of burial in clays are known in Russia.
The principle of sites selection for foundation of any type storage is based upon the selection of geological medium capable to secure necessary complex of toxic waste isolation conditions for storage projected term.
Principle of isolation, namely long term storage or burial, defines projected term of storage safety and technical principle of it's system.
Selection of sites for storages location could be realised basing upon two approaches: system and pragmatic. System approach comprises consecutive set of procedures from

specialised evaluation of the whole country territory aimed at promising geological regions and formations definition and carrying out regional investigations and R&D aimed at sites-candidates selection.
Pragmatic approach is usually realised in the area of economic or administrative region (or any other territorial object up to specific settlement with waste accumulations) and is concentrated upon the direct search of sites according to accepted safety criteria.
Procedure of regional investigations aimed at sites selection comprises selection of promising geological objects in favourable geological formation (or formations) on consecutive hierarchical levels: region - zone - site.
There are two methodological tools for selection, evaluation comparison and ranking: the set of criteria for selection (and exclusion) and the set of evaluation models of mining-geological group.
The set of selection criteria includes three groups: ecological-geological (or safety), socio-political and technological-economic.
The entire complex of investigations and R&D for sites selection and characterization comprises three stages: 1- reconnaissance stage, small scale subdivision of the region (conditionally corresponds with scale 1: 1 000 000 - 1: 500 000 of geological survey), 2- middle scale prospecting studies of promising zones having been selected in the limits of the region, selection of promising sites (corresponds scale 1: 200 000 - 1: 100 000), 3- sites characterization, large scale and detailed (corresponds scale 1: 50 000 - 1: 25 000 and 1: 10 000 - 1: 5000). This stage includes phases: prospecting and appraisal works, preliminary exploration and detailed exploration.
All the stages have to be accompanied with safety analysis, content of the latter depends upon storage facility target (i.e. principle of isolation, exploitation terms, character of waste etc.).
For location of nearsurface storages the most favourable geological media are shallow clay series characterised with sufficient thickness,mineralogical composition and geomechanical properties securing isolation function. The set of criteria for sites selection includes:

STRUCTURAL

The site ought to be located within geodynamically stable more or less monolithic block of Earth crust, in the distance from active disjunctive breaks (faults etc.), flexures, zones of discompaction etc. Host series have to be of sufficient geometrical parameters (thickness, area).

GEOMORPHOLOGICAL

Plain areas with minimal relief erosion and insignificant surface slope, outside of areas with dangerous exogenetic processes (landslides, karst, wind erosion), as well as rivers valleys, bogs, swamped areas, exposed to mudflow zones are favourable. Watershed areas are preferable.

NEOTECTONIC

Areas of active modern epeirogenetic movements (uplifts, submergence), faults, folding, volcanism, mud volcanism, salt and clay diapirism, as well as ones of active seismicity are unacceptable.

LITHOLOGICAL

Mineralogical composition and structural-textural properties stipulating geomechanical characteristics of host rocks have to secure mechanical and physical-chemical protective properties of geological medium. According to this condition host rocks should have low filtrating parameters and high sorption ability. Lythological criterion includes geochemical aspects (chemical composition, pH and Eh parameters etc.) determining migration and retard of toxicants.

HYDROGEOLOGICAL

Hydrogeological conditions have to secure maximum restriction for migration of toxicants having been released from the storage as a result of engineered barriers degradation. The main factors determining toxicants migration in aquifers are as follows: rate of infiltration, depth of aquifer, velocity and direction of underground water flow. Aquifer have to be removed from the level of a storage as much as possible (no less than 30 m).

METEOROLOGICAL

The total rate of precipitation should be minimum.

HYDROLOGICAL

This criterion assumes sufficient facility removal from superficial basins, considering the danger of floods, emergence breaks as well as infiltration and drainage.

CRITERION OF ECOLOGICAL LOAD

The areas with low protection of geological environment and underground waters have to be excluded. Areas with extremal contamination (for example Chernobyl exclusion zone) require special consideration.

CRITERION OF GEOLOGICAL PROSPECTS

It assumes minimum of site area prospects of minerals deposits and underground waters reserves.

SOCIO-POLITICAL GROUP OF CRITERIA

Socio-political group of criteria includes a number of influencing factors: the density of population, arrangement of settlements, industrial-urban agglomerations, objects of ecological, historical and economic significance, prospects of land use etc., as well as population acceptance of facility foundation.
For location of underground storages salt, crystalline (mainly granites) and clay formations are favourable and used.
Specially excavated and reworked openings of mines are in use. A set of sites selection criteria includes: structural, geomorphological, neotectonic, geochemical, hydrogeological (including hydrochemical), geomechanical, criterion of ecological load and of geological

prospects. Selection of favourable intervals in promising section of formation in the limit of the site is based upon the set of appraisal models: structural, lythological, geomechanical, considering hydrogeological conditions. Tasks and contents of the models differ for different types of formations.

Safety analysis is aimed at estimation of impact upon the biosphere. Final results of safety analysis could be considered as positive if the estimations show that toxicants dispersion resulted of facility engineered barriers degradation according to reference scenario do not represent danger to the population and environment (or nominally do not exceed existing national standards).

Planning and realisation of projects aimed at toxic and hazardous waste isolation in storages of nearsurface and underground types is the only solution acceptable from the economic point of view and satisfactory as to the environment safety for countries of transitional economics or suffering from political collisions and military operations as so as modern technologies of waste processing (utilization, destruction) need significant investments. Meanwhile the realization of such projects and national programs also needs international and regional co-operation.