

GEOTECHNICAL ASPECTS OF DESLUDGING SITES – SYSTEMATIC SOLUTION

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Motto: Theory without practice is useless and practice without theory is blind!

1. Introduction

Slovakia is a country with small area. The rock environment is, however, highly variable from the point of geology and hydrogeology, just like the inhabitants who produce waste in diverse activities. Officially registered desludging sites of Slovak Republic are shown in the Fig.1. These are defined (according to the ICOLD classification) as hydrological construction works of category I. to IV. and are subject to mandatory technical safety supervision. Together, these make 50 desludging sites with various types of deposited materials in various stages of their existence. Some of these have been reclaimed, many are in attenuated operation, other are in stage of intensification and some are regularly operated. Existence of desludging sites represents a wide set of geotechnical problems related to preparation, design, construction, operation, intensification, reclamation and use of this structures. Most of the deposited geomaterials are wastes from power plants and heating plants (cinders and ashes) and products of treatment plants for ores (flotation sludge). Sludge from chemical facilities does not have any uniform characteristics and each type of sludge has to be assessed individually.

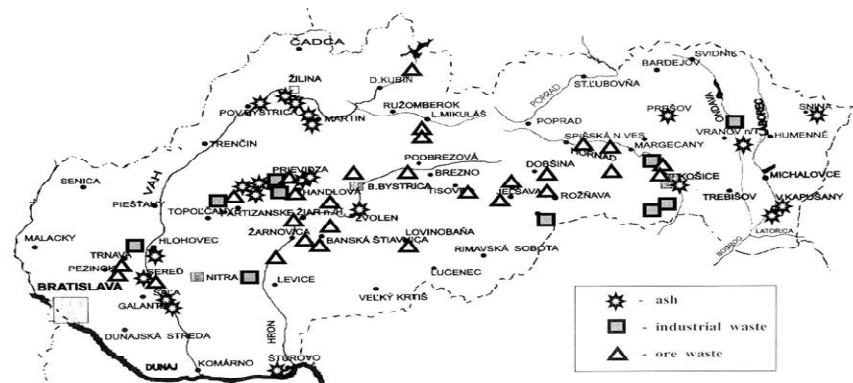


Fig. 1 Registered desludging sites in Slovakia

Desludging sites still represent costly, hazardous and demanding structures. Today, they are large dumps of unusable materials while tomorrow, they may become significant sources of raw materials. However, they will always be a long-term burden for the land. Even after their operation has ended, they still represent possible sources of accident for the surrounding environment. Accidents of abandoned non-operated desludging sites are not common but such events have been recorded. At present, it holds that any known method of waste elimination and processing has adverse effect on ecosphere.

2. Interdisciplinary character of desludging sites

Slovak standard uses the following definition for these technical works: Desludging site is naturally or artificially formed location on surface used for permanent or temporary depositing of sludge (waste), which is mostly deposited by hydraulic methods. The definition of desludging site results in its being classified as object studied by two disciplines: it is hydrologic work, i.e. engineering output of hydrologic construction and water management, although waste can be produced by power engineering, mining, metallurgy and chemical industry. Another group of sciences is the field of exploiting both metalliferous and non-metalliferous raw materials, the waste thus being only produced by mining and related activities. In general, desludging sites are classified by their origin of waste, location on surface (valley, hillside and plain, Figs.2 to 4), use of transport water (flow-through and circulation). Further, additional classification is conventional: elevation of dike system, total capacity, waste production, type of dike, flow rate of surface waters, method of elevating dike body, etc. It is obvious that desludging sites represent a set of works and burdens of various types, sizes, categories and stages of existence. They are objects of interest for organizations in the fields of survey, research, design, suppliers, investors, supervisory and legislation bodies and state authorities.



Fig. 2 Valley desludging site for metalliferous waste

The interdisciplinary character stems from overlap of application of natural sciences and technology with social sciences, also requiring collaboration from health sciences (both human and veterinarian). It is useless and unworthy to discuss the priorities of disciplines studying this issue. Rather, all knowledge should be employed, analyses accumulated and solution should be

searched for within appropriately defined legal frame and economically acceptable environment. Yet, we must not forget: *Scientists discover what is, engineers create what has never been, (Karman, T., 1936).*

An overview of registered desludging sites in respective regions of Slovak Republic is in Tab.1.

Table 1. Register of desludging sites in Slovak Republic

REGISTER OF DESLUDGING SITES IN SLOVAK REPUBLIC					
region	population	metalliferous desludging sites	ash desludging sites	industrial desludging sites	total
Bratislava	622,706	2	0	0	2
Trnava	561,525	1	1	2	4
Trenčín	599,214	2	3	3	8
Nitra	705,661	0	2	3	5
Žilina	697,502	4	3	0	7
Banská Bystrica	653,186	9	1	1	11
Prešov	807,011	0	2	1	3
Košice	778,120	9	2	5	16
Total	5 424,925	27	14	15	56



Fig. 3 Hillside desludging site of ash waste

3. Role of geotechnics

Geotechnics is science related to (through mechanics, mechanics of soils and rocks, establishment of buildings, underground engineering) and cooperating with geology, engineering geology, hydrogeology, geophysics and geochemistry, all environmental engineering activities. In life cycle of desludging sites, the geotechnics contributes to solving preparation and design, building and operation, intensification, rehabilitation and reconstructions, troubleshooting and accidents, reclamations, in attenuation stages and end of

operation, in long-term existence and introduction into harmless state. In practice, the state of desludging sites after their operation has ended cannot be deemed harmless because desludging site represents a permanent environmental burden to the land. Accidents are also caused by absence of monitoring, insufficient maintenance and expiration of service life. Destruction of dike may occur, overload or subsequent accident of the desludging site due to water in the desludging site body, because of climatic changes, dynamic effects or as a result of change of strength characteristics of deposited geomaterials, or through changes in soil structure interaction. The role of geotechnics is to solve the principal issues of desludging sites existence: stability (static and filtration), define risks (survey, design, operation, long-term existence) and propose monitoring (of water and its effects, deformation of the body, soil structure interaction).



Fig. 4 Plain desludging site of ash waste

4. Prognostic of desludging sites behavior

All prognostic methods are based on determination and use of defined analogy between reality and its computational expression. In geotechnical prognosis of desludging site behavior, we use methods, criteria and mechanical methodology, mechanics, soil mechanics and other scientific and technological disciplines.

Input data that are necessary for real prognosis of desludging site behavior are a set of information on geotechnical characteristics of deposited anthropogenic sediments, leakage conditions of the desludging site body, geotechnical properties of the underlying rock and desludging site dike, terrain morphology, hydrogeological conditions of the underlying rock, seismicity of the area and climatic conditions. Appropriate evaluation of monitoring and utilization of the results form an unavoidable part of the issue of desludging sites. It has to be stated that the sets of input data are often minimal, incomplete, insufficiently evaluated and documented and sometimes, the geotechnical data are completely absent.

Since 2003, we have been working on a systematic solution to predicting desludging site behavior in different stages of their existence (from determination and selection of geotechnical information to stability and risk analyses), [2] to [4]. We have proposed a method for unified summarization of data on desludging sites by so-called complex

monitoring. Gradually, we have evaluated and analyzed all legislatively monitored desludging sites in Slovak Republic. For each desludging site, so-called “Identification description of desludging site” has been created, which includes: identification sheet, technical-geological and hydrogeological condition of the site, present state, geotechnical parameters of geomaterials and prediction of desludging site behavior together with proposed measures and critical comments. This includes a list of used information sources. All data are processed in electronic form and they represent the basis for the database, which has to be supplemented and innovated in defined time intervals. Between 2003 and 2009, we have altogether evaluated 38 desludging sites with different type of deposited waste, out of the total number of 56 desludging sites. The proposal of geotechnical audit (Fig. 5) was created in 2006.

Geotechnical audit is defined as professional analysis of information on particular desludging site, creation of its identification sheet and method of adding input data for realistic prediction of its behavior. Geotechnical audit represents support input data for other interdisciplinary cooperation and evaluation of the desludging site or environmental burden (e.g. for contribution to and support of solving the issue using EU resources, establishment of environmental management system, economical savings in the future, benefits for business, management of administration organizations or owner companies, public relations, etc.) and is effectively beneficial for both present and long-term existence of desludging sites. It is not one-shot and definitive act. To make it economically bearable and practically applicable, it has to be repeated systematically in defined time intervals (e.g. according to desludging sites category or in regular time intervals) and a database of data on desludging sites (environmental burdens) has to be maintained and innovated continually.

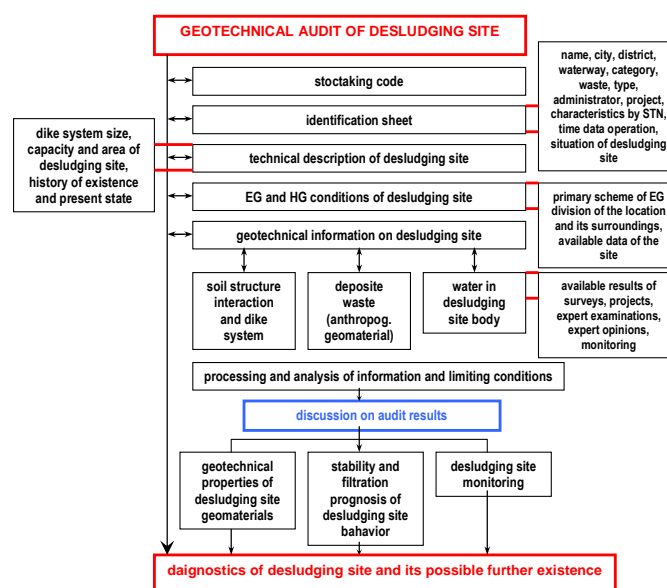


Fig. 5 Diagram of geotechnical audit (Masarovičová M., Slávik I., (2006))

5. Conclusion

Desludging sites are active structures, made in continuous operation out of anthropogenic geomaterials. Properties of materials deposited at desludging sites are different from those of soils and rocks. Issues of dike system stability, drainage functions, water leakage, filtration stability, liquefaction and seismic effects represent sources of engineering risk. Results in this field are always only a contribution to solving the interdisciplinary issue of desludging sites, which is demanding both in its theoretical and experimental (laboratory and field tests) aspects, including the scientific, innovative, methodical and technological relevance, because *'it is better to be probably right, than to be exactly wrong'* (Lacasse, S. (2002)).

Design of geotechnical audit (for particular desludging site, the scheme is always highly specific) is the result of our long-term research of geotechnical aspects of desludging sites, collaboration with administrators, designers, supplier organizations of these structures, employees of supervising and managing organizations and institutions. Research and solutions in the field are very interdisciplinary. They represent a symbiosis of scientific and technological knowledge applied through legal measures in environmental engineering. Audit, in the right sense, means investigation, evaluation, verification of correct functioning, providing response to the state in this case, relations and prognosis of geotechnical attributes of desludging sites while predicting the possibilities of their comparison.

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The above paper is based on our previous publications and results with sources cited therein:

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GEOTECHNICKÉ ASPEKTY ODKALÍSK – SYSTÉMOVÉ RIEŠENIE

Anotácia

Existencia odkalísk predstavuje množinu geotechnických problémov (prieskum, projekt, výstavba, prevádzka, intenzifikácia, rekultivácia a využívanie odkalísk). Otázky stability hrádzových systémov, funkcie drenáží, priesaku vody, stekutenia a seizmických účinkov sú zdroje inžinierskeho rizika. Geotechnický audit je profesionálna analýza informácií o konkrétnom odkalisku. Predstavuje podklad pre interdisciplinárnu spoluprácu a posúdenie odkaliska.