SITE REMEDIATION

RESTUARATION DE SITES

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SYNOPSIS

A century of prosperous industrial activities and some few decades of intensive use of hazardous chemicals and petroleum products is to be compared to an environmental impact situation which might go on for centuries or even thousands of years if no counter measures are taken. We have only recently been aware of this situation and the means we have got so far are still in the development stage.

Special attention is paid on the fact that remediation not only concerns the cleaning up operations but also tracing of sources and pathways of the emissions as well as control of the works and monitoring of the effects of the remediation measures. Remediation operations cover a broad range of different methods many of which are related to geotechnology. In a schematic diagram the status of different possible methods is presented. It is evident that the geotechnical science plays an important role in the remediation of contaminated sites. The contribution also define the different operations which relate to the disciplines involved. The geotechnical issues are especially emphasized and the attention is put to urgent development needs in the field of environmental geotechnology. The needs to develop special systems to facilitate the interaction between experts/operations within the different disciplines involved are especially stressed.

INTRODUCTION

It is a fair guess that the beautiful logotype if this conference symbolizes the stress distribution in the ground caused by all kinds of natural or man-made structures on the Earth. However, it could also represent the stress on the ecosystems caused by polluted grounds resulting from human activities. In this sence it acts as a spectacular warning sign saying "clean up the polluted grounds in order to ensure that human progress will be sustained and that the natural resources will be conserved for future generations".

Site remediation is most often not only a question of cleaning up the ground. It is also a matter of tracing the sources and pathways of the emissions and of controlling the effects of the counter measures taken – e.g. by monitoring. In these efforts the geotechnical science plays an important role. The "know how" of geotechnicians and engineering geologists has to be used.

NEEDS FOR REMEDIATION

In many cases the needs for remediation is very obvious. During decades pollution has taken place affecting objects like wells and endangered species. To assess the total impact situation, the damages and the spreading of pollutants, requires a lot of knowledge of soils and rocks as well as of the geohydrological situation. Most fluid emissions interact with the ground which is one of the reasons for bringing geotechnical resources to the projects. Already in the localization of the pollution, a basic knowledge of the existance and appearance of soils and rocks of the ground is of vital importance. The localization of the pollution also uses the knowledge of fluid flow in geological settings. This could be a complex matter of e.g. multiphase flow. In the assessment of the impacts already caused and the potential impacts if no counter measures are taken, the attenuation of pollutants in the ground is another matter of basic importance.

There are no simple set of limit values on pollution levels at which humans or the natural environment is damaged. The sensitivity of an area and the exposure situation varies within wide ranges. In urban areas where remediation measures are common the potential impact to human health is of primary concern. This potential risk is very much governed by the possible future situation. If the pollution is not mobile and will not degrade into more poisonous and mobile phases, it becomes very much a question of exposure or not. The counter action to be chosen could simply be to cover the pollution in order to avoid direct future contact with the contamination. In case of mobile, harmful and persistent substances we have to act regardless of possible exposure and a full remediation program is called for.

OBJECTS OF REMEDIATION

The most complex sites which need to be restored are the industrial sites. A great number of such sites, abandoned and in use, need to be reclaimed. especially those which have been hosting (or still are) wood treatment facilities, gas work sites, petroleum refineries, pesticide and fertilizer factories and storage facilities, gas stations, paint factories, chlorine-alkali plants, iron works, steel factories, metal foundries, metal finishing facilities. Other sites may be related to old waste dump sites, industrial or municipal, or pipe lines, sewage systems and underground storage facilities, especially those containing petroleum.

MEANS OF REMEDIATION

The remediation methods presently available could be divided into three main groups according to their basic functions on the source of emissions:

- Concentration and treatment of emissions
- Destruction of pollutants
- Immobilization of pollutants

In table 1 the 12 most important remediation methods are described. Only three of them are categorized as established methods. The others are looked upon as innovative methods which still have a great development potential. However, this classification does not mean that the innovative methods are not in current use or that the established methods are not worth developing.

Table 1. The status of methods involved in site remediation. Modified from Helldén, unpublished (1993).

Methods	Innovative	Established	Organic compounds	Inorganic compounds	In situ	On site	Ex site
Concentration /treatment							
Vacuum extraction	X		X		X		
Soil washing	X		X	X	X	X	X
Electro-kinetics	X			X	X		
Thermal treatment	X		X	X		X	X
Filter treatment	X		X	X		X	
Destruction techniques							
Incineration		X	X			X	X
Biological treatment	X		X		X	X	X
Chemical oxidation	X		X			X	X
Dehalogenization	X		X			X	X
Immobilization techniques							
Stabilization / solidification		X	X	X	X	X	X
In situ vitrification	X		X	X	X		
Encapsulation / disposal		X	X	X	X	X	X

Most of the methods classified as "concentration/treatment" and "immobilization" are related to conventional geotechnical techniques and civil engineering such as drainage of soils and rocks, ground improvement, sealing operations in the ground and road constructioning. On the other hand, the main group "destruction" being dependant on biological and chemical processes contains less of geotechnical issues.

BASIC DISCIPLINES OF REMEDIATION

What especially characterizes remediation operations is the multidisciplinary issues which are involved. Therefore, it is necessary for geotechnicians to cooperate with other scientists and to organize the work accordingly. Dividing the works into the four successive main operations the following disciplines may be involved:

Tracing emissions and conducting environmental impact assessment studies

Physics	Transport and fixation processes of contaminants
Chemistry	Organic, inorganic, biochemistry, analytic
Geology	Soil and rock properties, local conditions, geophysical investigations
Hydrology	Surface and ground water conditions at surveys and siting
Ecology	Impact surveys, sensitivity of surrounding areas, limit value establishments
Public health	Impact assessments on wells, dusting, airborne emissions, workers safety

Restoration operations

Soil mechanics	Material properties, foundation, deformation of soils, stability analysis
Rock mechanics	Material properties, stability analysis
Civil engineering	Road constructions, sealing operations, well hydraulics, water diversion, land use plans, erosion protection
Hydrogeology	Water infiltration, percolation rates, sealing material
Economy	Investment needs, management and disposal costs, interest rates, cost sensitivity analysis, financing

Monitoring

Ecology	Areas sensitive to impact situations, protectable areas
Geology	Geological settings, aquifers
Geohydrology	Water balance situations, stream courses, siting of monitoring wells
Civil engineering	Well hydraulics

DEVELOPMENT NEEDS

Both the surveys for confining the remediation area, the preinvestigations for designing the remediation measures and the conducting of the remediation works are often costly operations. Therefore, the optimization of the predesign and design efforts will be of outmost importance bringing the attention to the multidisciplinery character of this work. Methods are available for most of the individual operations but there is a lack of systems to manage and optimize the work.

Conventional geotechnical field methods can not always be applied in the way they normally are used. For instance, the application of chemical or micro-biological analysis with low detection limits generally requires clean technology in sampling. In situ measurement methods to be used at soil and rock investigations are constantly developed. In all field investigations at contaminated sites, special safety considerations are called for as regards the field workers.