CONTAMINATED GAS SITES

THE MANAGEMENT OF

APPROACH TO

COBENHAGEN - 1997

World Gas Conference

International Gas Union
This report is based essentially on the exchange of experience of the IOC members. It leads to control ecologically and economically remediation operations and the future uses of the sites involved. The report recommends an approach to the development of a problem-solving approach, taking into account local and national regulations and the economy. In the absence of universal and final solution to problems about contaminated sites, different aspects are studied: regulations, scientific background, methodology, etc. This report aims to give a clear idea of current problems and to promote a synthesis of approaches used to deal with these problems.

Environmental remediation of coal has generated chemical compounds considered as undesirable in the context of regulations with public authorities. Environmental assertions about the development of coal and sale of the site, liabilities, environmental impact on health and of the contaminated pollution a health risk and contamination of the real environment have to take into account several difficulties and uncertainties: determination of the type of problems encountered, the management of this type of problems, the presence of pollutions in the soil of former plans is a preoccupation that industrial.
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This paper focuses on the issue of management of contaminated sites and the most

common problem. It is based on experience gathered from a wide range of companies, world-wide. The issue is compounded by residues from former use, if also gives information about economic aspects.

Chemical and environmental actions and strategies for sites owned by gas industries that may be

appropriate treatment procedures. Its aim is to formulate a logical, practical approach to

The potential risks associated with contaminated land can be estimated using data from

The need for better, modern, environmental legislation and practice requires higher standards to be

although these sites were properly operated in compliance with the environmental standards

which was used for a number of specific contamination processes such as coal gasification.

Chemical residues from previous activities. Chemical contamination may be compartmented by

redevelopment of urban landscapes rather than an excuse to exploit 'green gold'.

There are very many detected sites throughout the world of which a significant number are in

INTRODUCTION
For the determination of guideline values, in any case, it is important to clarify the methodology and the assumptions taken.

In many situations, the real exposure may differ from the estimated exposure, making the values of some toxicological effects of some toxicological substances above "normal" levels.

The procedure used to choose the criteria is a point of disagreement. Even if research is

investigation.

Table 1: Types of criteria used in different countries to define a "polluted" site

<table>
<thead>
<tr>
<th>Country</th>
<th>United Kingdom</th>
<th>Switzerland</th>
<th>Spain</th>
<th>The Netherlands</th>
<th>Japan</th>
<th>Hungary</th>
<th>Germany</th>
<th>Finland</th>
<th>Denmark</th>
<th>Canada</th>
<th>Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criteria</td>
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<td>*</td>
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<tr>
<td>Characteristics</td>
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<tr>
<td>Resources</td>
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<td>Remarks</td>
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</tbody>
</table>

Table 1 shows the basis chosen by some countries to define a contaminated site. The criteria-based approach (or assessment of a specific contamination risk-based approach) and the difference between "normal" and "polluted" can be judged against some standard values and "polluted land" are both widely used to indicate a case of soil pollution. Not all countries have a formal definition of soil pollution and the terms "contaminated land"
Figure 1: By-products of a manufactured gas plant

The historical sites of gas industry which are most concerned by environmental problems are

1.3 Application to Gas Industry

be clearly explicit, for example the projection of groundwater or of human health on the site.

I.2 Risk-based Approach

they are not relevant for a low sensitivity usage, such as a car park.

The most realistic way to use guideline values is to take into account the present or intended
What cost-effective techniques can remediate the site if remediation is necessary?

* Does the site meet the current regulations?

* Is the site free from any hazards, in its actual and future use?

Therefore, for each historical site, these questions have to be asked:

<table>
<thead>
<tr>
<th>Heavy metals (trace)</th>
<th>Coke industry, energy</th>
<th>Coke</th>
<th>Special oxide</th>
<th>Chemical Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanides (complex)</td>
<td>Chemical industry</td>
<td></td>
<td>Benzene, toluene, xylenes</td>
<td>Chemical industry</td>
</tr>
<tr>
<td>PAH, Ammonia, Phenols</td>
<td>Ammoniacal water</td>
<td>Fertilizers</td>
<td>Industry : Wood treatment</td>
<td>TR</td>
</tr>
<tr>
<td>PAH</td>
<td>Public works (roads) : oceanic</td>
<td>Poly cyclic aromatic hydrocarbons</td>
<td>TR</td>
<td>TR-products</td>
</tr>
<tr>
<td>Potentially harmful compounds</td>
<td>Possible uses</td>
<td>Coke</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: MGP by products: current uses and harmful compounds

Shown in table 2, compounds considered as harmful (for example for the quality of underground water) as being considered as potentially contaminable. Indeed, many of these by-products comprise because of the number and type of its by-products, every manufactured gas plant site has to
The risk of breathing is very low because there is a very small (non-representative) flow of gas from the pollution in the ground. The only place where the gas could accumulate is the cellars or building; therefore an analysis of the air would provide valuable information.

The pollution is dispersed in the area, there is no risk of chemical contamination by children if pollution is near the surface.

2.2.1. Pollutants

The compounds liable to be breathed are hydrocarbons (phenolic, BTEX, aromatic, or hydrocarbons (can have, usually complex), sulphur compounds, etc).

The pollution which is liable to be ingested or ingested is blue matter, also called spent oxide.

2.2.2. Textiles

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2.2.3. Soil

The situation is different for soil contamination or groundwater contamination.

- Chemical by-product that presents a possible nuisance on health or environment.
- Abnormal presence of a chemical product in a natural zone (soil, underground water).

The term "contamination" is not clearly defined. Contamination can be defined as following:

2.1. Introduction

2. WHAT CONTAMINATION?
Water pollution. Water is also considered an important resource which may be required for drinking. Because pollutants can flow out of the site and therefore an obvious direct pathway for contamination of groundwater is clearly regulated in every country. It is a major issue.

Figure 3: Risks during ground work

Beyond the site boundary, or polluted dust being released in the air, which can affect workers or residents downwind. During work on the site, there also is a possibility of gas (phased or other low hydrogen fractions).

Figure 2: Pathways for the migration of volatile pollution through the soil

and during dry, windy weather at peak soil disturbance. Precautions have been taken so that nobody is at risk of polluted ground.

Workers are the most exposed to risk during investigations, remediation and redevelopment of ground work.
Migration of pollutants in the aquifer is transposition of pollutants in the soil until they reach the aquifier. The second is the movement of pollutants from polluted soils to the different levels. The first stage

2.3.3. Migration Parameters

**Figure 4**: Possible pathways from a contaminated land

Surfing migration in groundwater is an important route to control risks, and contamination levels increase the total burden of pollution. Therefore, more such places can accumulate pollutants from different industries and migration of pollutants down to a river or lake can affect aquatic wildlife and Surface water. Use

Injection wells for crops is the random and uncontrolled manner of drilling and groundwater finds its way out to the surface by two major routes: wells from which people

2.3.2. Pathway

Cyanides - complex of free (and organic, BTX or PAH). The compounds which are liable to be found in the groundwater are inorganic (ammonium, polynomials, etc.)
be taken. When any work is envisaged on the site, the risk of contamination
human health or the environment is groundwater contamination.
contamination with some clean soil. In the long run, the main way the pollution can affect the
through simple actions such as reducing accessibility to the site, remediating the ground or
When no interventions are made on the site, the hazard remains fairly low and can be limited

2.4. Conclusion for risk assessment

Table 3: Ratio of pollution velocity in groundwater, "velocidad de permeabilidad en evapotraspiación",

<table>
<thead>
<tr>
<th>K (molatm cm⁻²s⁻¹)</th>
<th>Pollutant</th>
<th>Net infiltration</th>
<th>Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
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<td>0.000</td>
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<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Groundwater velocity is a function of soil and the type of pollutant in

The example given in Table 3 illustrates the influence on the migration velocity in

soil particles and polluted water. When pollutants reach the aquifer, they can be dissolved in water or fixed on small particles in

Groundwater also depends on the depth of the aquifer. This migration is slow but steady with interstitial contact and some attention

Rainwater can wash soluble compounds by contact with polluted soil and carry them to the

In the ground but a low speed because of their high viscosity. However, they can spread

The "flow of pollution", also called non-aqueous phase liquids (NAPL), can move downward

Horizontal migration

Indeed, a porous structure at the bottom of the aquifer can allow this pollution to flow along the side of the

Great care is demanded when bringing up drilling because this may speed up the migration.

modifying the process.

Rainwater can wash soluble compounds by contact with polluted soil and carry them to the

vertical migration

moves faster in sand than in silt and can be stopped by clay. Time needed to reach the

reduces on the water surface. The speed depends on the type of ground - for example, in

Therefore, simple actions such as reducing accessibility to the site, remediating the ground or

Conclusion for risk assessment.

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vertical migration. Groundwater also depends on the depth of the aquifer. This migration is slow but steady with interstitial contact and some attention

Rainwater can wash soluble compounds by contact with polluted soil and carry them to the

vertical migration.
3.2. Land-use approach

Figure 3.2 of the site, etc...

of the legislation, use of standards or guideline values, possibility of taking into account the

Groundwater, surface water, the workers or public health

link the potential for soil contamination to the potential for pollution with laws concerning

3.1. Overview

3. REGULATIONS AND REQUIREMENTS

Post Remedial actions

Post Remedial actions are possible when cleaning matters are economically or technically feasible.

Remediation with minimal efforts because the environmental impacts are constantly

good compromise among the various points of view: it allows a "softer", more affordable,
especially in countries which have multifunctionality as a principle. Post Remedial actions is a site in a

specific and site-specific regulations with the legislation. It would be much better to propose a land-use policy

a lot of sites likely to be contaminated. It would be much better to propose a land-use policy

of their sites. In technical conditions and a lack of money, as well as concerns usually own

community that takes a multifunctionality. Here we now adapt the pragmatic approach for most

sensitive than a recreational area - and more economical, especially for large sites. Even

how account the particular use of the site. This approach seems logical - a car park is less

the other hand, some communities consider only the protection of risks that could arise

situation. Such policies also prevent environmental problems and changes in remediation. On

consideration of the cost-efficiency of the cleaning. Some counties base their policies on local

The strategic approach is very different if you look for multifunctionality or if you take into

of the regulations.}
### Table 3: Diversity of legislation concerning former industrial sites

<table>
<thead>
<tr>
<th>Country</th>
<th>Soil Act</th>
<th>Environment Act (considering soil)</th>
<th>other Acts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td>Waste (contamination before 1972-74)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Waste Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Industrial Plans - Water - Waste</td>
</tr>
<tr>
<td>United Kingdom</td>
<td></td>
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</tbody>
</table>

This diversity is confirmed by a more detailed review of the characteristics of national regulations as it is given below:

- **Australia**: Legislation for each state generally an Environmental Protection Act. State Environmental Agency can force industries or landowners to cleanup (if possible).
elaboration of regional programs or short term remediation measures

Regional plans including guidelines and a priority list of former industrial sites

Hungary

application of information when sale
new legislation voted in 1996: Principle of "polluter pays"

Germany

national gas company and Ministry of environment
since 1996, most of IGCP sites have been rule by an agreement between French
regional legislation case by case (pollutant owner/administration)
polluter pays
application of information of the buyer of a site (former activities, existing pollution)
application of law about industrial sites

France

information of waste management act, water act or public health acts

Finland

sell
regional authority registers polluted sites for which permission is needed for new use or
polluter pays “

Denmark

Legislation
federal legislation applied on land owned by federal state or where there is no local
Legislation for each province

Canada

environmental issues shared between federal government and provincial governments
1990: Preliminary investigation of every WFPs

In the future, new Environmental Protection Act will be more restrictive

(colonial solution - reasonable cost)

The selection of the clean-up method is based on "best practicable environmental option"

The sites (water)

The main motivation for clean-up is the re-development of sites or pollution coming out of

Later sites are managed by governmental agencies, smaller site by local authorities

Legislation comprises Environmental Protection Act and Water Resources Act

General policy decided by government

UK

Spanish

Federal Environmental Protection Act: basis for supplementary measures by the

Switzerland

"National Plan of Contaminated Land " is in project

Guidelines based on specifications of quality and risk analyses considerations.

Which has a draft project: "Quality criterion about contaminated land. Security

Resolution for some communities are under preparation in particular in Catalonia

The Netherlands

Planning elaborated for investigation and remediation of priority sites

In the long term: evolution of policy which aims to make site specific

If multihazardousness is not feasible or too expensive then other options are taken:

Real = multihazardousness

Multihazardousness is not obtained

Local authority can demand cleaning and post remedial monitoring when

Application of law by province

Polluter pays principle: If the polluter is unknown, owner is responsible

Soil Protection Act including Guidelines

Norway

"Land Act (old) and Pollution Control Act: National Survey of Hazardous Waste (Slate

1990: Planning elaborated for investigation and remediation of priority sites

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Multihazardousness is not obtained

Local authority can demand cleaning and post remedial monitoring when

Application of law by province

Polluter pays principle: If the polluter is unknown, owner is responsible

Soil Protection Act including Guidelines

Japan
3.5 Conclusions on Regulations
The name of the pollutions that may have been produced or used there:

- the different plans that were in operation on the site and their location:

The following points are to be investigated:

- residues which may have been produced or used at the time the site was operating.

The purpose of the historical study is to collect all data on the presence of any polluting residues that may have been produced or used at the site. The study aims to assess the following stages:

4.2.1. General Methodology

4.2.2. Investigations and Risk Assessment

These steps bring into play a wide variety of technologies and skills.

4.1. Code of Practice

4 TECHNICAL MANAGEMENT
4.2.4 Site Investigations

On the basis of these preliminary studies, the decision is made as to whether to conduct more detailed on-site surveys or to rely on the observations and analyses of other parties. If an on-site survey is also to be conducted, the former, present and future occupancy and use of the land, former, present and future occupancy and use of the land, downstream of the site, water table utilisation (existence and characteristics of pumping upstream and downstream), all pollutants, drainage systems, streams, ditches, canals, severs, etc., surface and underground hydrology: location and direction of flow of the water, geologic context: nature and thickness of the strata, geophysical background, assessing the risks of possible pollutant transversal, especially outside the site, documenting interviews with the environmental characteristics to be taken into account in subsequent investigations on the areas where pollutants were handled. Historical research is determinant in the investigation strategy. The findings can help focus activities on the site since the gasworks were shut down.

4.2.5 Documentary Research

Historical research is determinant in the investigation strategy. The findings can help focus activities on the site since the gasworks were shut down.

4.2.6 Historical Research

Historical research is determinant in the investigation strategy. The findings can help focus activities on the site since the gasworks were shut down.
Consequently, direct investigation by means of drilling or excavation should also be used to complement these gas sampling methods. The latter are useful either in initial discovery or to confirm the presence of pollution.

A small number of pollutants such as volatile hydrocarbons, coloformic acid, and many other substances require different detection modes. All of these methods are limited to a certain degree. The less complex the methods are, the less data they provide. Even those that are more complex are often limited to a small scale. Some of these substances are detected through other methods, such as analysis of samples or by direct observation. The methods for analyzing gases and volatile compounds in order to identify substances are also limited to a certain degree.

The characteristics of the site's formation, areas of rock, or mineral deposits may influence the detection of pollution. The interpretation may be complicated by the specific characteristics of the environment and geology. Observations by geophysical methods can yield numerous measurements and determine the characteristics of the soil and ground water. However, this does not necessarily mean that all possible locations can be detected. Direct investigation is still required.

Table 4: Investigation techniques applicable to former gasworks sites

<table>
<thead>
<tr>
<th>Sampling parameters</th>
<th>Depths of soil samples</th>
<th>Ground water</th>
<th>Pollutant identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical methods</td>
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<tr>
<td>Detection of volatile compounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis of gases in soils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geophysical methods</td>
<td></td>
<td></td>
<td>Pollutant identification</td>
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<tr>
<td>Drilling</td>
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<td></td>
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<tr>
<td>Extraction</td>
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<td></td>
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<tr>
<td>Visual examination</td>
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<td></td>
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<tr>
<td>Contaminated soil</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
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</tbody>
</table>

The pollutants may have been produced by activity on the site in the past. Characterizing sites in underground water tables and searching for pollutants identified in the contaminant soil and characteristics of the soil and characterizing the nature and concentration of the pollutants.
hazardous to health if absorbed through the skin, ingested or inhaled, which assumes
the manifesting residues present in the soil, though possibly harmful, are only
the analytical techniques.

However, accurate the audit is, it may involve uncertainties due to the samplings and
monitoring. It needs to take the following points into consideration:

Risk assessment conditions the decisions concerning subsequent site remediation and
concentrations of pollutants in groundwater;
samples are high or very sophisticated methods may be used, such as modeling the changes of
pollutants in soils with simple dichotomization of risks and pathways. In some cases, when the
methods used in risk assessment may vary greatly. They may involve no more than a

4.2.5. Risk assessment

Procedures and techniques are often difficult to operate efficiently in soils
degraded because of the coexistence of pollution and geology. On the other hand, analytical
investigations of geochemical data is unavoidable because it can highlight these
phenomena. It is necessary to choose a better understanding of how certain pollutants had
an impact on the soil. Therefore, a prior knowledge of the soil and history is the main guide in
choosing the drilling locations. Surveys may be made for the quantity of storage facilities
(certain drainage structures, sewerage, former canals, etc.).

The location chosen for the precursors must take into account the influence of
the direction of flow of the water table, so as to provide a "zero" share of the table.
Very over time. At least one precursor must be located underground, relative to the
precursors must be located so as to indicate the direction of water flow which may

Categoric rules may nevertheless be formulated:

the investigations and analyses on the one hand, and on the other, costs and deadlines.
In an environmental audit, a balance has to be achieved between the number and accuracy of
This part deals with the aspects of remediation of former industrial sites, once decisions have been taken to treat the pollution identified during the investigation of the site. Treatment of pollution in former industrial sites may represent a considerable economical stake.

4.3. Treatment Procedures

community.

be made, while avoiding vastly over-scaling interrelations, which are very costly to the use of the groundwater and streams, etc. By compiling all these factors, reasoned choices can and consequences of the compounds decided. The risks of interaction, the dilution factors, the compounds' toxicity (especially concerning the main contaminants), and the amount of mobility in water and in (retention capacity, i.e., concentration characteristics in terms of mobility in water and in (retention capacity, etc.)

determination of a great many transfer parameters - soil permeability and absorption capacity, determination of a great many transfer parameters - soil permeability and absorption capacity.

This kind of approach, while satisfactory in principle, is rarely used because it requires a thorough study into the water table and spread of the pollutants

8. Leachate from storage facility into the water table and spread of the pollutants

9. Leaching of contaminated soil by water infiltration

10. Dissolution in dust

11. Direct contact with contaminated soil or water

Industrial site.

contact exists. Various scenarios of compound transfers may be considered for a given case.

To react to control, particularly when a property is likely to be sold to another party.

The effects elicited with gasworks sites on human health since they still down more than 30 years ago.

... (specification, temperature, physical and chemical characteristics of the soil, land occupancy, etc.)

They may vary and are not easy to characterize: many soil weather conditions and quantities particularly because they depend on a large number of factors which

transfers in the groundwater or atmosphere. Such transfers are difficult to measure.
Information may be insufficient to design remedial operations precisely. In particular:

- Presence of wells or collection points for water.
- Presence of pollution in soil, air, and water.
- Chemical identification of the pollution including possible pollution from outside the site.
- Approximate location of polluted soils and a clear estimate of their extent.
- Depth of groundwater.
- Local ecological structure.
- Location and contour of remnant source faciliies.

Historical and site investigations of course give information that can be useful in designing remediation.

4.3.2 Information available at the end of risk assessment.

4.3.2 Site Treatment: Initial State.

Specifically, understanding the process requires a large amount of knowledge in different measurement techniques are very diverse and sometimes based on complex technologies.

Specifically, this specialty that is not always compatible with the other.

Measurement is a combination of civil engineering and chemical engineering. Each quantity of pollution to be treated.

Even after the investigations, many uncertainties remain about the nature and own pollutions and history.

A former industrial site is often a superposition of several plans, each having its own processes. This complexity covers different aspects.

Solving these questions present many difficulties due to the complexity of the measurement.

Optimization of the costs induced by the remediation.

Warminess about the quality and the efficiency of the measurements.

Remediation costs can be very high and have a major impact on the management of these sites. Two key questions are generally raised during the design and the selection of remediation.
To remove undetectable waste of soils to a waste disposal site, we refer to the following techniques: another method is the treatment of polluted soils in an inert matrix, such as cement. Another method is scale-by, for example, isolating the polluted part of a site. It may also be achieved by removing the name of the pollution of pollution may be addressed on a microscopic scale. Lining the mobility of degrading the effects of pollution. This limitation, which does not change the number of concentration of pollution may be addressed on a microscopic scale.

- Application or modification of the use of the site:

Environmental risks:

Three major families of solutions may be considered to remediate a site (i.e., reduce the environmental, point of view. The environmental point of view must be considered. It is important to keep in mind that remediation operations, which include environmental, transformation, emissions of pollution during the different phases of remediation and the site after environmental remediation must lead to a reduction in risks to health and the site (soils, water, etc.). Remediation of a site aims to reduce the extent of human impact on the environment.

4.3.1. Objectives of remediation operations

4.3.3. Principles for remediation

Feasibility tests:

Currently, the subject of discussion is the feasibility of solutions, as pollution can be detected in soils according to their prime use. More often, target values for soils may be certain indications for soils, sometimes according to discharged from the process; indicators about the celling for pollution contained in water or air that can be identified of the pollution, what needs to be considered in the remediation; identification of the risks for which a remediation operation has to be carried out.

After presentation of the risk assessment, the representative of the public authorities gives positioning the storage facility, etc.

4.3.2. Rules defined by the regulators before the beginning of the remediation operations

- The size and concern of a storage facility are also sometimes not well determined. Different remediation (this difference may be in one way of the operational or size revealed with reasonable accuracy the size of polluted zones, if it is not too small, the difference revealed)

Very often, there are 100 low soil and water operational analyses to determine
In some cases of complex pollution, several treatments have to be applied, one after another.

- Waste disposal.
- Biological treatment (use of micro-organisms to degrade or extract pollutants).
- Subsequent neutralization.
- Physical and chemical treatment (chemical transformation of compounds such in pollution).
- Thermoreaction (decomposition or change of complexes of vitamination or mineral).
- Physical containment of the pollution.
- Chemical containment of the pollution.

The main methods are the following:

4.3.3 Possible treatments for each type of pollution - Different treatment methods may be

Another way of classifying pollution is to consider the chemical nature of the pollutants:

- Polluted liquids: steel, concrete or brick structures.
- Former waste whose physical aspect may vary: liquid, solid, pasty, etc.
- Air.
- Water (old process water or underground water).

Several types of pollution may then be considered:

Pollution on a site may differ considerably depending on the media in which it is trapped.

4.3.3 Types and names of pollution

Only the last two solutions are genuine remediation solutions and as such will be discussed in

Elimination or transformation of pollution. This may be achieved by different ways.
applicable to do the job; such as the company having conducted the risk assessment.

Specifications are generally derived by public authorities or by the owner (or contracts

4.2. Specifications on treatment

making for the entire operation.

The responsibilities of each of these representatives have to be clearly defined in the decision:

- Citizen representatives
- Manager of the site
- Insurance companies
- Laboratories or consultants supervising the work for the owner or the administrative:

In some cases, must be added to the above:

- Company contracted for remediation operations
- Representative of public authorities
- Representative of the company responsible for the site as owner or former operator

The remediation operations always involve several parties.

4.4. Organization of the remediation

<table>
<thead>
<tr>
<th>Type of Pollutant</th>
<th>Thermal</th>
<th>Biological</th>
<th>Physical</th>
<th>Chemical</th>
<th>Disposal</th>
<th>Water</th>
<th>Air</th>
<th>Sediment</th>
<th>Soil</th>
<th>Silt</th>
<th>gravel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground Water</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface Water</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soils</td>
<td></td>
<td>U</td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
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<td></td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollutants</td>
<td></td>
<td></td>
<td></td>
<td>U</td>
<td></td>
<td></td>
<td>U</td>
<td>U</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal Ash</td>
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<td></td>
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<td></td>
<td></td>
<td>U</td>
<td>U</td>
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</tr>
</tbody>
</table>

Table 5: Summary of the possible treatments applicable to different natures and types of pollutants.

Table 5 presents an overview of the possible treatments applicable to the different natures and
substances in polluted soils, to be biologically relevant...

operations (examples: absence of metals in waste to be incinerated, presence of other
- extraction of the presence of explosive compounds likely to influence the treatment
- determination of specific sizes distribution in the soils
- behaviour of the groundwater
- determination of the hydraulic characteristics of the subsurface and the hydrogeological
- treatment
- determination of more accurate estimates of the quantities involved in the different
- necessity. Their main objectives are generally the following:

According to the nature of the possible treatment, additional investigations are often

4.4. Comprehensive investigations - selection between different pollution and clean parts of

- accuracy of control during treatment
- choosing the most cost-effective methods
- modifying the objectives of condition of treatment
- The results of feasibility tests can have major impacts:

- estimate the quantities of the different by-products resulting from treatment
- give the name and quality of the different by-products of the treatment
- determine the ranges of pollution for which the different methods are applicable

The results of the feasibility tests encountered on the site. In particular, they have to

- to verify the feasibility of the different methods proposed. They are especially
- feasibility tests are very important in the remediation process. Basically, they are conducted

4.4.3. Feasibility tests

- time table
- in the remediation
- organisation of the work: who decides what, responsibilities of all the parties involved
- site survey after remediation
- health and safety conditions
- checks imposed during the process
- concerns, risks involved for pollution flow, influence of pollution...
- the results for the treatment which can be expressed in different ways: direct pollutant
- the types of risks that have to be reduced or eliminated by the remediation operation
- the area concerned by the remediation operation

Specifications must comprise:
<table>
<thead>
<tr>
<th>LIQUID</th>
<th>SOLID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Products&lt;br&gt;Re-use&lt;br&gt;Elimination of the different&lt;br&gt;Events&lt;br&gt;Outgoing (gases, liquids, solids)…&lt;br&gt;Control of the quality of the different&lt;br&gt;Introduction in the process&lt;br&gt;Surfactants, nutrients…&lt;br&gt;Washing, introduction of additives; oxidizers; soil&lt;br&gt;Pre-treatment: grain size sorting; soil&lt;br&gt;Analysis&lt;br&gt;Temporary storage for selection after&lt;br&gt;Decantation&lt;br&gt;Pumping&lt;br&gt;Handling of the soil</td>
<td></td>
</tr>
</tbody>
</table>

The operations of treatment compose several phases that are summarized in Table 6:

4.4.5 Operation of the treatment

Different kinds of pollution, the use of both simple measuring techniques, which are generally specific to laboratorium, the use of kits or simple measuring techniques, which are generally specific to soils can be analyzed. Different methods may be used for analysis: chemical analysis in selection is not easy to do. It is often necessary to create a temporary storage area where the patients are not contaminated. Good selection avoids the useless introduction of clean soil into the process (and on the cost (c.g. selection is an important step). The quality of selection has a major influence on the success of treatment, corresponding to the different treatments and identifying "clean" soils which has not to be treated. These additional investigations may be made before or during the treatment, for example, while the extractions are being made.
particular, it is important to determine what uses are possible - landfill, building foundations, etc., even if there is residual pollution.

In the case of the possible uses of treated soils or water in a very important topic. In particular, the fate of remediation by-products must be defined before the work is begun.

4.4.7. Post-remedial use of treated products

Particular consideration when polluted media are handled, transported or stored.

Pollution is remediated because it represents a risk. Primarily, this risk has to be taken into the health and safety provisions must be defined with care. It should be kept in mind that the

It is important to verify that the remediation is not a source of pollution.

In the case of on-site remediation, conservation of the quality of the water and of the air:

- Monitoring of the quality of the environment on the site during handling and remediation
- Monitoring of the quality of the soil or water remaining on the site
- Monitoring of the contents of the different outputs of the remediation operation

It is interesting to list the main types of checks that may be made all along a remediation operation.

Monitoring and controls are important for assessing remediation quality and observance of regulations.
5 Economic Aspects of a Treatment Operation
Give reliable values.

also be very high, but it is so much related with the site characteristics that it is difficult to
substances such as oil or heavy hydrocarbons. When groundwater has to be cleaned, costs can
used. Table 7 gives costs often given for the different types of remediation for soils polluted by
For remediation, costs depend on the nature of pollution and the type of remediation that is
groundwater risk assessment studies (have to be made). Selling operations, it can be much higher for large sites or when specific studies (modeling

Sovets of Remediation.

Nevertheless, the examination of some costs gives a rough indication about the economical
the specific characteristics of the site and of its surroundings. It is so complex. The situation is very different according to the country, costs highly depend on
Costs of site remediation are difficult to detail in particular because experience of remediation

5.2.2. Remediation costs

have an area lower than 5 hectares. The situation seems to be similar in other countries.
area of these former gasworks sites is very often small. In France, more than 90% of sites

very often located in urban areas.

In the USA, Environmental Protection Agency announces about 1500 former gasworks sites,
between 7500 and 12000.

In Europe, we can estimate that the total number of former gasworks sites is comprised

- The Netherlands: about 250 sites.
- France: about 900 sites
- Germany: about 2000 sites

different countries are the following:

The situation of former gas industry sites is particular. These sites are essentially gas plants
5.3 Prediction of costs: uncertainties and difficulties

Adapt the survey of the neighborhoods.

Influence to reduce the global cost of remediation operations.

The quality of investigations and direction of risk assessment can have a major influence. The global cost will be comprised between 0.5 Million US$ much higher than the cost of thermal desorption will be comprised between 0.5 Million US$. The cost of polluted soil remediation is much higher than the cost of biological treatment for example. 5000 tons of polluted soil remediated by thermal desorption represent very often several thousands of tons. It appears that a cost of 50 US$ per ton of soil remediation is much lower than the cost of biological treatment. As a result, the global cost of remediation must be under the global cost of remediation. If we consider that on a lot of sites, polluted soil contaminated by global cost of remediation or by the global cost of remediation, we can consider that the global cost of remediation is much lower than the global cost of remediation. Nevertheless, this information shows the importance of the quality of investigations for different techniques. Many parameters can modify the costs such as:

<table>
<thead>
<tr>
<th>Remediation (biological treatment)</th>
<th>Remediation (heat treatment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 to 200 US$</td>
<td>100 to 500 US$</td>
</tr>
<tr>
<td>100 to 500 US$</td>
<td>500 to 1000 US$</td>
</tr>
<tr>
<td>500 to 1000 US$</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Estimation of remediation costs
5.4. Organization of remediation operations

The uncertainty can be reduced all along the remediation through an appropriate organization. Among the aspects on which the management of a remediation can be very assessed: the feasibility of the cheapest techniques must be assessed.
A typical economic balance of a remediation operation is given in Figure 5:

- Costs of remedial actions (land not sold or not rent during the duration of remediation).
- Variations of the value of the land induced by remediation.
- Costs of surveys of the site after remediation.
- Costs of the soil introduced in the different remedial processes.
- Costs of the different remediation operations including the costs during the remediation process.
- Cost of the design of the remediation process.
- Costs of preliminary investigations necessary to define nature, location and volume of pollutants.

The evaluation of the economical balance of a remediation operation must take account of the following costs:

It is important to realise that there are many costs that can be at least as much higher than the economic balance. This is often the discussion about remediation costs focuses only on remediation processes. It is aimed to present shortly which types of expenses can occur during such an operation. Very much as shown in the previous chapter, remediation is often a complex operation. This chapter
Industrial sites and former spoil heaps sites also have a feedback effect, with critics and businesses may avoid building on former industrial sites being acceptable to industries that have to maintain their competitiveness. It can be noted that on contaminated land in rural or areas of ambitious environmental policy, such a policy rules on contaminated land in respect of a policy of ambitious environmental policy. Such a policy requires public authorities that have to get a compromise between very severe number of remediation operations.

The building activity which involves a demand on land and therefore can increase the supply of remediation technologies change very fast, experience 80% on the first remediation operation is short and should lead to a significant reduction of costs.

When a former industrial site is sold, it will concern the approach that is now present in many countries.

Industrial and local authorities:

- Former industrial areas comprising often many sites, on which an association of authorities, remediation of a large number of sites, and sites belonging to the companies that plan, in accordance with public demand should be more precise and more regular. The market that composed during the last ten years in which there were complaints or pressure from media is gradually.

Major evolution should appear in the next few years on the economical aspects.
CONCLUSION

The first time they have to deal with potentially contaminated sites, managers or industrial.

Environmental challenge changes very fast: science and technology are in progress and research and next use of the site.

We can get the basic rules that can help them to deal efficiently, in the future with problems that are growing quickly. By keeping on exchanging their experiences, gas companies need to be aware of possible risks.

This includes the exposure of people and the present methods. For instance, research and studying risk, including the exposure of people and the present knowledge in geology, chemistry, and toxicology. Looking for simple and simple quality, the issues, lastly a pragmatic approach must be taken, using as much as possible to combine data and to define optimal strategies for treatment. Even if it takes several years, care must be taken about the reclamation of potentially contaminated sites can help to combine data and to define optimal strategies for treatment. Even if it takes several years, care must be taken about the reclamation of potentially contaminated sites can help to combine data and to define optimal strategies for treatment.
REFERENCES