SESSION 2 - SUSTAINABLE REMEDIATION OF CONTAMINATED LAND

CHAIR: MR. ADRIEN PILON, CANADA

CO-CHAIR: MRS. JUDITH LOWE, UNITED KINGDOM

INTRODUCTORY REMARKS OF THE CHAIRMAN: Mr. Adrien Pilon, Biotechnology Research Institute

It is a great pleasure for me to be here. My name is Adrien Pilon from Canada.

As you can see on your agenda, we have four speakers this morning. Mrs. Judith Lowe from the UK, Mr. Peter Oggier from Switzerland, Mr. René Goubier from France and myself. We would not like to get into philosophical discussions on sustainable development but we would like to, at least, stimulate some discussions on sustainable remediation of contaminated land.

I would like each speaker to take about 12-15 minutes and allow at least five minutes for questions at the end. If we still have time at the end of this session, we would like to have an open discussion on a few specific questions, themes or topics that you would like to raise about sustainable remediation of contaminated land. Before I give the floor to Judith Lowe, I have a special request and just for the matter of transition, Harald Kasamas would like to say a few words about land management.

“In the hurry of my presentation, I forgot to mention certain issues. I would like to say that the Risk-Based Land Management Report is currently under construction. We have appointed an editing team of two key experts who are currently working on this Risk-Based Land Management report. These experts are Prof. Judith Lowe, who will be making the next presentation, and Dr. Joop Vegter from the TCB, Netherlands.

Their input and their extremely encouraging work is highly acknowledged by the whole CLARINET team and the key point of this Risk-Based Land Management concept is to find joint objectives with other areas, like Soil Protection, Spatial Planning and Water Protection. This is the key aim of the Risk-Based Land Management concept. Thank you for your attention.”

Now I would like to introduce Prof. Judith Lowe. A little bit of history, Judith did chair a session like this in Nottingham in 1995 and I think it is important to have this perspective of other meetings and to see how the evolution in this area is taking place and now I would like to welcome Judith Lowe to talk to you about the CABERNET network in Europe.

Please Judith.

Note: This text was prepared by the compilers from Mr. Pilon’s recorded presentation.

CABERNET: A EUROPEAN INITIATIVE TOWARDS THE SUSTAINABLE MANAGEMENT OF CONTAMINATED LAND

Speaker: ***Mrs. Judith Lowe***
CABERNET
United Kingdom

CABERNET?

- Concerted Action on Brownfield and Economic Regeneration Network
  - University of Nottingham, UK & Umweltbundesamt, Germany
- Proposal under the 5*th* ***Framework*** programme of the European Commission: key action 4:
  - “City of Tomorrow and Cultural Heritage”
  - “In negotiation”

Why This European Initiative?

Initiated from CLARINET, in particular WORKING GROUP 1: “Brownfields in Europe”

CLARINET WORKING GROUP 1

- Considered that “Brownfield sites” can present a particular set of circumstances in dealing with contamination
  - Site preparation
  - Land use planning needs
  - Economic pressures
  - Legal framework
- Explored the link between environmental issues and spatial planning/urban development issues
- Examined national backgrounds, policies and approaches
- Prepared a report
- Defined Brownfield sites:
  - have been affected by the former uses of the site and surrounding land;
  - are derelict or underused;
  - have real or perceived contamination problems;
  - are in mainly or partly developed urban areas;
  - require intervention to bring them back to beneficial use.
- Concluded that:
  - Brownfield sites are a growing strategic challenge across Europe.
  - Integration of environmental issues with spatial planning issues is complex and not fully implemented.
  - There is a lack of existing tools and guidance.

- Sustainable solutions are urgently needed.
- Exchanging information and experience is vital for the effective development of new solutions.

CABERNET PROJECT

- 48 funded participants from over 20 countries
- Multidisciplinary
- A range of stakeholders

CABERNET OBJECTIVES

- Better awareness and shared understanding of Brownfield issues
- A conceptual model for Brownfield issues
- Coordinated research activities across different sectors and countries
- Identification of best practice approaches and other tools

KEY THEMES

• Policy and regulation • Citizen participation • Professional skills	Cross-cutting issues
• Economic issues • Social and cultural issues • Environmental issues	Sustainability components

CABERNET OUTPUTS

- Enhanced sustainable rehabilitation of Brownfield sites from:
  - new framework of integrated scientific thinking
  - new transferable approaches
  - improved practices
  - benchmarks
  - new initiatives…

BROWNFIELDS ARE AN OPPORTUNITY

Not a threat….

FURTHER INFORMATION

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SUSTAINABLE REMEDIATION OF CONTAMINATED LAND - THE CANADIAN EXPERIENCE

Speaker: ***Mr. Adrien Pilon***
NRC - Biotechnology Research Institute
Canada

Sustainable Development in Canada[1]

- Canada ranks sixth in the world for its standard of living.
- Compared to other OECD countries, Canada is a large consumer of natural resources and energy, and consequently a large generator of pollution and waste.
- Over time, Canada's economy has had an impact on the environment.
  - In Canada, sustainable development is perceived as a major challenge by various actors in the public, private and non-profit sectors.
  - Challenge = combining economic growth in a context of dynamic demographic evolution with the preservation of the country's natural assets.

Canada's Constitution – Environmental Policy

- Federal Constitution
- Ten provinces and three territories
- Shared responsibilities for environment policies, regulations, guidance documents
  - Difference among provinces for the use of natural resources
  - Different priorities, given particular natural and economic conditions of provinces
- Canada is bound by bilateral and multilateral agreements such as NAFTA.
- 1990, Federal Government launched the Green Plan.
- All provinces also established sustainable development plans in the early 1990's.
- 1995, Guide to Green Government
- 1999, Environment and Sustainable Development were named as priorities.
- February 2001, innovation for sustainable development, quality of health services, preservation of natural spaces; greater focus on the "social leg" of sustainable development

Sustainable Development in Canada

- "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs". (Definition in Auditor General Act, 1995)
- First emerged from the environment community
  - Primary focus of government is the interface between environmental and economic issues i.e. the need to enhance "environmentally sustainable development".
  - Social issues as a central part of the sustainable development paradigm is more recent.

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1 Source: OECD 2001

Actions Towards Sustainable Development

- 1993, creation of the National Roundtable on the Environment and the Economy (NRTEE)
  - Mainly focusing on economic and environmental aspects
  - Specific project on Brownfields
- Commissioner of the Environment and Sustainable Development
  - Independent audit of the Federal Government
- Canadian Environmental Assessment Agency
  - Integrates environmental considerations into planning of projects
- Office of Environmental Health Assessment (EHA)
  - Toxic Substances Research Initiative
- Canadian Council of Ministers of the Environment (CCME)
  - Mechanism for providing a multi-level framework on environmental issues

Canadian Council of Ministers of the Environment

- Canada-wide Accord on Environmental Harmonisation (1998)
  - Includes the "Polluter Pays Principle"
- Canada-wide Standard for Petroleum Hydrocarbons in Soil
- Development and Application of Soil Quality Guidelines
- Contaminated Sites Classification System

Other Initiatives of Canadian Government Related to Sustainable Development:

- Toxic Substances Research Initiative (TSRI)
  - Helping to reach sustainable development goals through improving the knowledge base needed to define and reduce the risks of adverse effects of toxic substances.
- Canadian Environmental Protection Act (CEPA)
  - To conduct research on endocrine disrupting substances.

Contaminated Sites in Canada

- Operating industrial sites, mining, petroleum production, petroleum distribution and storage. Estimated number: 200,000
- Orphan sites (including old landfills) and federal sites in Canada: 2,000
- Brownfields: 3,000 NRTEE, 1998
- Landfills
- Military sites
- Airports
- DEW Line (North of Canada Defence System)
- Harbours
- River sediments

Risk Analysis - Contaminated Sites Management

- Major issues, in Canada for contaminated land management
  - Human health risk assessments, developed with health and environment departments
    - develop site specific criteria
    - establish remediation or mitigation measures
  - Ecological risk assessments
    - increase use in non-urban sites, e.g. oil production
    - also used for technology evaluation purposes
- Risk-Based Corrective Action (RBCA) adopted in some provinces
  - Development of toxicity data for different contaminants, e.g. hydrocarbons, explosives and metabolites
- Canadian Council of Ministers of the Environment (CCME) Contaminated Sites Classification System: potential risk/ranking

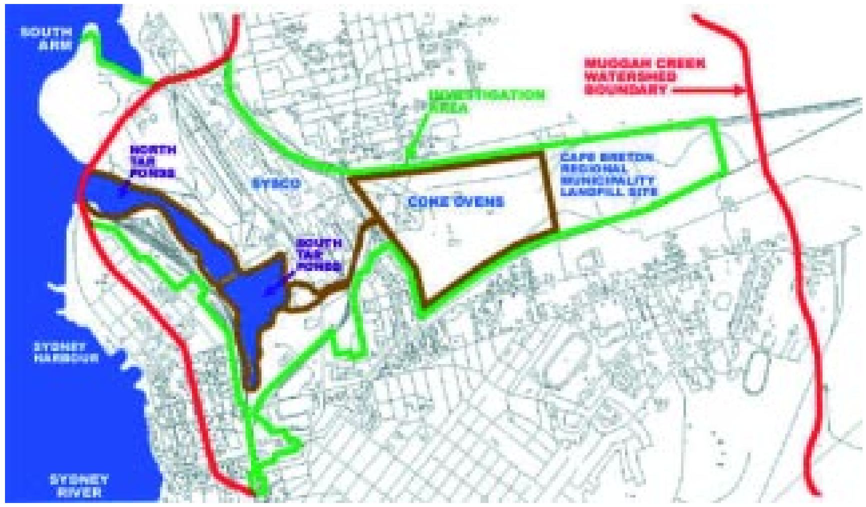
Regulations and Policy

- Each of the 10 provinces and 3 territories in Canada has its own Policy, Environment Protection Act and Regulation.
  - Differences exist in soil and groundwater quality guidelines and contaminated sites management practices.
  - Polluter Pays Principle is enforced in Canada and in the provinces.
  - Soil and groundwater quality criteria are not regulations but guidelines.
- Harmonisation programme was initiated by the CCME.
  - Hydrocarbons, human risk assessment, ecological risk assessment, soil quality guidelines, site management, etc.
  - Not all provinces in Canada adopted CCME guidelines.

Sustainable Remediation of Contaminated Sites - How Applicable?

- Historical contamination
  - "Major contamination problems are resulting from past and historical industrial activities; environmental practices were not implemented and therefore prevention did not occur."
  - No existing environmental legislation
  - Environmental and health impacts were not suspected; limited knowledge of properties of contaminants (mobility)
  - Lack of knowledge
- New or future contamination
  - More prevention oriented by site owners and industry
  - Environmental regulations and policies
  - Industry and government developing Sustainable Development and Environmental Management (ISO 14000, Eco-Efficiency)
    - Increased control over discharge, spills, etc.

Case Study - Sydney Tar Ponds



Sydney, Cape Breton

- Over a century of steel industry with a coke oven plant operation
  - 700,000 tons of toxic soils and sediments (PAH's, PCB's, metals, As, Pb, Cd, etc.)
- In the middle of the city
- Impacts on health, terrestrial and aquatic environments; fisheries banned (15 sq. km)
- Hundreds of Millions $ for cleanup to acceptable levels by public; CCME guidelines
- Past cleanup failed; new process to select solutions
- Only solution to reach guidelines: incineration
  - Problem with the technology
  - Search for solutions?

Steel Plant near the city

Major difficulties with social aspects

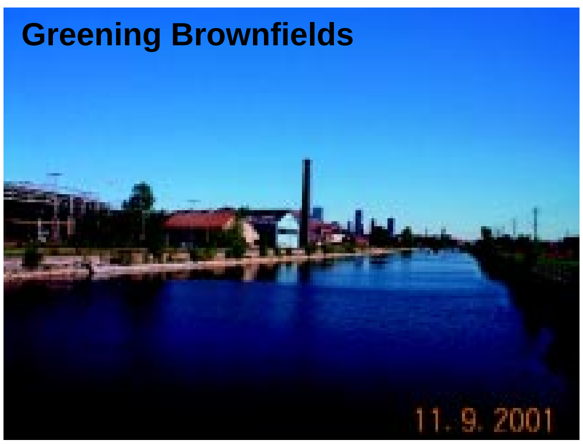
- PAH's, As and other contaminants near houses
- Ongoing investigations and human risk assessments
- Difficult communications with citizens
- Citizens leaving
- Government buying houses and properties

Coke oven plant

Case Study - Lachine Canal, Montréal

"After being closed for 30 years, the Lachine Canal soon will wind its way back into the hearts of Montrealers. The city of Montréal and the Government of Canada are investing more than $80 million to redevelop the riverbanks and open the canal to boating in the year 2002."

- Redevelopment of riverbanks: residential, commercial buildings
  - Environmental technology and management
  - Demonstration experimental station
- Several new construction projects; joint projects with municipality-government-promotors-citizens
  - Economy: increased activity (programme REVI-SOLS, Québec), Canadian government investments
  - Social: local citizen groups involved in the redevelopment activity and for risk-based decisions, consultation for land development plan, joint project Montréal Centre of Excellence in Brownfields Rehabilitation (MCEBR)
  - Environment: contaminated sites being restored or managed, based on risk assessments
    - Mixed contaminants; no cost-effective solutions yet; dig and dump still the No. 1 solution
    - Contaminated sediments still represent a major issue because of costly solutions



MCEBR Future Experimental Station and Public Information Centre

Case Study - Explosive Contaminated Sites

- **Developing knowledge on fate and bioavailability of explosives in soils and groundwater**
    - Remediation technologies
    - Natural attenuation
    - Risk analysis

- **Improve environmental management process**
    - Cost-efficiency
    - Decision making based on sound technical and scientific data environments
    - Adapted solutions to specific sites

Environmental risk assessment and phytoremediation

Photo 3: Collection of Contaminated Soil

Case Study - Moncton, New-Brunzwick “Closing the Loop” - Canada Lands Turns an Old Railyard Into a Recreation, Commercial and Housing Area

- **Priority: sustainable development approach**
  - Environment
    - Site assessment, risk-based corrective actions implemented, waste recycling programme (lead contaminated soils to a smelter), groundwater remediation and monitoring programme
  - Social
    - Public information on a regular basis = transparency
    - Recreation areas for kids
    - Hi-tech industrial park = investments and brainpower
    - Quality of life improved
    - Greening downtown
    - Health risks removed
  - Economic aspects
    - Cleanup costs: $13 Million CDN (8 M €)
    - Investments for redeveloping all areas
      - Technology park: $40 Million
      - Recreation area: $14 Million

Conclusions

- Principles of sustainable development can apply to contaminated sites.
- Economic incentives are frequently needed;
  - High value properties = good incentives; we see less redevelopment occuring in regions with weaker economies.
  - Added value vs vacant/Brownfield;
    - The same principle is difficult to apply to remote sites (e.g. mining).
    - Environment aspects prominent in other cases; still an incentive?
  - Costs of remediation need to be low or very well adapted to situation; however dig and dump is cheaper but less adapted to sustainable solutions (long-term liability).
  - Needs for developing adapted methods for contaminated site management; decision process is crucial and requires a good understanding by stakeholders.
  - Liability aspects is still a barrier.
- Environmental aspects more taken into consideration
  - Better knowledge of contaminants
  - Better risk assessment tools
  - Mother nature capacity to “digest and support” load of contaminants (ConSoil, 2000)
  - Cost-effective treatment methods
  - Recycling of debris and treated soil

- Social aspects; the key!
  - Most important that they be understood by the public and stakeholders at large
    - Education process required
    - Long-term, step-by-step
  - Better acceptance of decisions if transparent process
  - Quality of life because it is a very important driver for investments
  - Reduced health effects
  - Greening vacant spaces
  - Urban and territory planners; need to integrate environmental aspects as well
    - Sustainable cities and regions
    - Reduced impact on Greenfields

“WHEN DIGGING IS CHEAPER THAN SEALING”

(COMPARISON: DECONTAMINATION VERSUS CONTAINMENT)

Speaker: ***Mr. Peter Oggier***
Ecolisto
Switzerland

Economic aspects are of great importance for the evaluation of the remediation techniques to choose. While comparing costs of a complete decontamination of a polluted site with costs of a set of containment measures, the costs for long-term maintenance and for the replacement or restoration of the sealing, drainage and treatment systems are often underestimated or not taken into account at all. The calculation method of Discounted Cash Flows allows a proper comparison of the total costs of remediation options. Varying important elements such as the initial investments and the duration of maintaining technical systems in function lead to additional economic information very valuable for the choice of remediation measures.

Considering also aspects that are very difficult to translate into reliable figures, such as:

- the remaining risks of containment measures for the environment due to unexpected effects,
- the low efficiency of treatment measures for emissions because of the transfer of persistent pollutants instead of destruction or degradation,
- the assessing of the time period necessary to reduce the emissions to a tolerable level, and
- the financial risks for the public due to insufficient guarantees for the covering of costs occurring in the far future,

the method of complete decontamination has to be chosen, even if - at a first glance - this causes higher costs than containment measures.

1. Introduction

Claiming sustainable solutions for contaminated sites means carefully considering ecological, social and economic aspects. If this is not done, problems might only be transferred instead of solved: transferring problems to future generations, to another medium (e.g. from the soil into the water or into the air) or to another place in the world - and thus to other people - are intolerable solutions.

Regulations in Switzerland and in many other countries allow several contaminated land remediation methods to reach the main objective that is: to stop emissions at the source, also in the long run.

In practice, the choice often has to be made between complete decontamination and a bunch of measures aiming at containing the pollutants in place and/or to reduce and treat emissions from the site as long as necessary according to specific legislation on the quality of groundwater, air and soils.

In this paper focus is laid on the economic aspects that have to be considered if the best method of remediating a contaminated site has to be evaluated.

2. Comparison: Decontamination versus Containment

To be clear on the notions used (in the short form) we present what we mean by:

(complete) decontamination All hazardous substances are destroyed or removed from the site. After a complete decontamination, the source of adverse effects is totally eliminated. All existing environmental regulations (mainly concerning emission or immission limits and quality standards or protection targets respectively) are respected. No other measures will be required, neither in the short nor in the long run, and no dangers for persons or the environment remain. The multifunctionality of the site is completely restored.

containment Several measures out of a whole package are taken to stop the source of emissions, i.e.:

- to decontaminate, at least partially
- to confine the remaining pollutants
- to avert the danger of future contamination
- to control and, if necessary, to treat the remaining emissions over a long period of time
- to provide the necessary financial means
- to guarantee, if necessary, the compliance with user restrictions

Seeking for a sustainable solution in a specific case asks for considering and comparing all ecological, social and economical aspects. In this paper we concentrate on the most convincing arguments: the costs.

Cost calculations are made in every case, but: are all the cost elements and the time factor taken into account?

In a small study, the Swiss Agency for Environment developed a decision tool. Discussing the main elements lead to a list of arguments that help the responsible authorities to push sustainable solutions and to prevent remediation methods that are selected mostly because of economical, but incomplete considerations.

3. Important Factors for Calculating the Total Costs of Different Remediation Methods

In the study mentioned, the costs of complete decontamination are compared with those of a containment solution as defined above.

Some elements are more or less the same for both remediation methods. Of course they might be of different importance in a specific case. The following costs can be left aside for a general comparison:

- investigations and risk assessment
- monitoring and urgency measures before remediation
- juridical investigations
- elaboration of the remediation project
- information of the public
- access to the site and installations

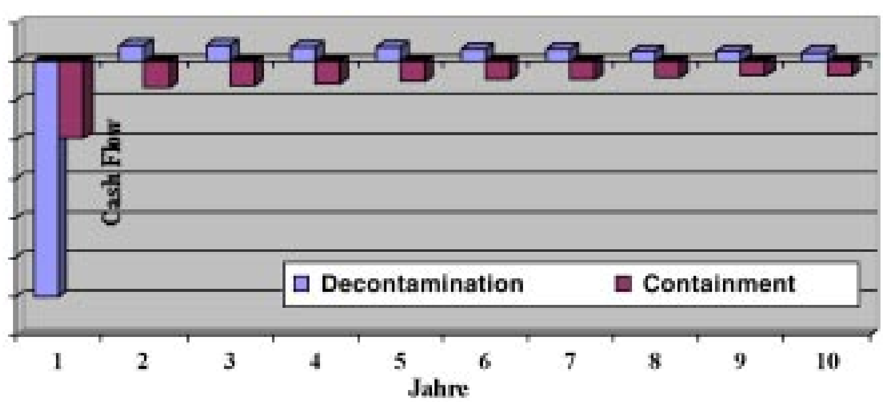
Other cost elements may differ considerably and therefore have to enter into the comparison:

for the decontamination:	**for containment measures:**
excavations and transports	excavations and transports
proper treatment of the wastes (*in* or *on situ*, outside the site) or depositing on a secured landfill	proper treatment of the wastes or depositing on a secured landfill 'sealing' measures (including all measures to prevent emissions from spreading by sealing off the surface, building containment walls, etc.) drainage of leachate and gas, construction of technical systems to reduce and treat emissions (water and gas) running, maintaining and if necessary replacing or restoration of technical systems guaranteeing long-term containment and allowing regular monitoring
technical planning and supervision	technical planning and supervision
measures necessary for the use envisaged after decontamination	measures necessary for the use envisaged after the initial works carried out
check of the results achieved	check of the results of the measures carried out and long-term monitoring
income after remediation	income during and after containment measures
capital costs	capital costs
insurance	insurance

4. Calculation of Costs

To compare investment costs of different projects usually the method of Discounted Cash Flows (DCF) is used. The effective flow of cash in every year is calculated and then discounted with a rate of interest to the date of the first payment. The resulting total amount of money, the Net Present Value NPV (Barwert, "la valeur actuelle de flux des dépenses") is the sum one has to dispose of at the beginning of the exercise to cover all costs at the fixed future dates.

5. Cash Flows: Visualised and Commented



In the case of decontamination:

Remediation measures cause high costs (negative cash flows) in the first year. As the decontamination is complete, there will be no maintenance or other costs in the following years. More intensive use of the site may lead to higher income (positive cash flows).

In the case of containment:

Measures for partial decontamination, sealing off, construction of drainage and treatment systems etc. cause much lower costs at the beginning than in the case of complete decontamination. But in spite of a (slightly) higher income through the use of the site, there are also negative cash flows in many following years due to the maintenance costs. The size of these flows is decreasing due to the effect of discounting to the starting point.

6. A (fictitious) Comparison: Complete Decontamination versus Containment Measures to Use an Old Dump Site as Housing Area

To test the effects of altering the parameters of the calculation, “model remediation” of former dump sites have been calculated (see boxes below). Some parameters are highly influencing the results, given as Net Present Values (NPV) for both solutions, the decontamination and the containment.

It is obvious, that in a specific case the important parameters have to be determined as accurately as possible, according to local conditions, in order to get a reliable comparison. This comparison gives, as should be stressed once more, only economic arguments for those who have to pay for a remediation according to the Swiss regulations. Checking for the sustainability of the different remediation options should, of course, also include aspects of the public economy, such as the comparison of the different degrees of damages to air and water. Such costs are not covered by these calculations, as polluting water and air up to concentrations defined as still tolerable is free of charge.

‘Model Remediation’ of dump sites

(Parameters chosen according to the supposed content of the landfills A to C, see below)

Surface:	10,000 m^2 (1 ha)	
contaminated volume:	100,000 m^3	
percolation:	750 mm/y	

Decontamination:	30 - 60,000 m^3 wastes	to be incinerated or treated
	30 - 40,000 m^3 wastes	to be deposited on sanitary landfill
	0 - 30,000 m^3 wastes	to be deposited on landfill for ‘inert’ materials
	wastewater	7,500 m^3/y (40% of precipitation of 1.5 ha) (pumped+treated)
Containment:	initial costs:	15 - 35% of decontamination measures
	maintenance:	4 - 6% of initial costs per year
	monitoring:	20 – 40,000 CHF
	time period:	20 - 200 years
Parameters:	(real) interest rate:	2% (1 – 3%)
(Swiss conditions)	planning + supervision:	25 – 35% of investments (in Swiss prices)
	misc./unexpected:	5%
	surplus in income:	30 - 40 CHF/ m^2/y (agriculture <=> industry)

Case A: **“Community Landfill”**	decontamination	30,000 m^3 incinerated 40,000 m^3 on sanitary landfill 30,000 m^3 on lf. for inert materials
	income surplus (decontam.)	30 CHF/ m^2
	planning + supervision	25%
	containment: initial costs	15% of decontamination
	maintenance	4%
	monitoring	20,000 CHF
	time period	25 years
Net Present Value **NPV**	**decontamination**	**Mio 17 CHF**
Net Present Value **NPV**	**containment**	**Mio 6 CHF**

Case B: **“Community and Industrial Landfill”**	decontamination	40,000 m^3 incin. (partly high Temp.) 40,000 m^3 on sanitary landfill 20,000 m^3 on lf. for inert materials
	income surplus (decontam.)	40 CHF/m^2
	planning + supervision	30%
	containment: initial costs	20% of decontamination
	maintenance	5%
	monitoring	30,000 CHF
	time period	50 years
Net Present Value **NPV**	**decontamination**	**Mio 32 CHF**
Net Present Value **NPV**	**containment**	**Mio 22 CHF**

Case C: **“Industrial Landfill”**	decontamination	60,000 m^3 incin. high temperature 40,000 m^3 on sanitary landfill
	income surplus (decontam.)	40 CHF/m^2
	planning + supervision	35%
	containment: initial costs	30% of decontamination
	maintenance	5%
	monitoring	40,000 CHF
	time period	100 years
Net Present Value **NPV**	**decontamination**	**Mio 86 CHF**
Net Present Value **NPV**	**containment**	**Mio 92 CHF**

Initial investments

.... for decontamination

Digging, treatment of contaminated land (with adequate techniques and capacities available), restoration of the surface according to the use foreseen and fees (mainly planning and supervision) are the main elements that may lead to very high initial costs. As these costs have to be covered at the very beginning and are only lowered slightly by the discounted amounts of the surplus in income of the following years, the initial costs will be practically identical with the Net Present Value (see schematic figure below).

Treatment has to be done according to the chemical and physical properties of the wastes dug out. Obviously, chem.-physical treatment or high temperature incineration of hazardous wastes cause very high costs.

.........for containment measures

Depending on the local conditions (quantity and quality of pollutants, topography, subsoil, groundwater occurrence and importance for drinking water supplies, techniques to adapt, etc.) the initial costs may vary between a small and a relatively high percentage of the initial costs of a complete decontamination (approx. between 10 and 35%). A direct comparison with the initial costs of decontamination is easy, as the discounting effect on the initial costs, to be covered in 1 to 5 years, is nil or may practically be neglected.

Running and maintenance costs

But source for great surprise may be the maintenance costs over the long period as well as the costs for the reparation or replacement of parts or of the whole technical containment system. The life span of pumping equipment e.g. is only about 5 years or sometimes even less, the one of technical systems, such as liners or concrete constructions, might be decades, but in some cases insufficient to do it without replacement before the end of the containment measures.

Duration of containment measures

And of course, very big uncertainties may also lay in the assessment of the time period necessary to reach fixed maximum emission levels or set quality standards due to:

- actively washing or stripping out pollutants,
- natural attenuation due to adsorption, dilution and/or degradation effects, and
- combinations of these processes.

These processes depend on many parameters, of which mainly the toxicity, the biodegradability and the vulnerability of the site are obviously of great importance.

Rate of interest (real values)

Interest rates may differ considerably from one country to another. But instead of using nominal values and executing the necessary amendments because of inflation, real values for rendering the calculation easier can be used. For European conditions, an average real interest rate of 2% allows a reliable assessment of the costs. If the interest rates are much higher, then containment measures are feasible, as the high discounting rates considerably reduce the net present value of high maintenance and repair costs in the future.

Benefits achievable by the use of the site during and after remediation

As the surplus in income by more beneficial use of the surface after remediation is the only positive contribution in the case of complete decontamination, local conditions and the type of use allowed are essential. In Switzerland this value may vary in a very wide range according to the degree of integration of the site in spatial planning:

(mandatory) use as forest	income of the site may practically be nil or even have a negative value, as timber sales do not cover maintenance costs in most cases (in the case of containment and sealing of the top, the use as forest is hardly feasible, as measures to prevent roots from destroying the cover are very costly)
agricultural land	varying between less than 1 to 2 CHF per m^2 and year in the case of arable land
industrial use or rural residential areas	10 to 30 CHF per m^2 and year (calculated as 5% of the value, i. e. of 200 to 600 CHF per m^2)
residential areas in towns	20 to 100 CHF per m^2 and year (calculated as 5% of the value, i. e. of 400 to 2,000 CHF per m^2)

This situation calls for close co-operation of all actors responsible for: spatial planning, land developing, financing, politicians and the general public.

Other cost elements

that are very hard to number may influence the comparison very much, such as:

- gain or loss of image of a company;
- not fulfilling prophecy concerning:
  - longer duration of containment measures
  - dealing with unexpectedly hazardous degradation products
  - slower degradation velocity
  - very poor longevity of technical systems;
- availability of newer and cheaper technologies;
- remaining risks in the case of containment.

7. Conclusions (as input for further discussions)

The discussion of these cost elements should give us additional hints to develop catalogues of criteria, under which conditions a specific solution can be accepted. In such a way one can get a set of arguments to favour a complete decontamination of a contaminated site, even if the costs seem to be exorbitant.

No decontamination

in combination with measures simply to contain the pollutants in place ("static containment") is only acceptable, if:

1. the quantity of persistent pollutants in total is "small" (i.e.: as concentrations, as loads........);
2. the vulnerability of the environment is "small" (definition?);
3. the conditions in the subsoil are very well known and the techniques well appropriate to the local conditions, so that a high level of security is given;
4. the function of the containment over a very long period is guaranteed and doesn't need any maintenance at all;
5. the remaining risks are small; and
6. any future interventions are guaranteed.

No or only partial decontamination

in combination with a bunch of different other measures to stop the source of contamination ("dynamic containment") is only acceptable, if:

1. all the measures are
    - compatible with the environment,
    - economically feasible,
    - up to the state of the art,
    - can be controlled, repaired or replaced over the necessary period of time, and
    - thus guarantee controlled and environmentally compatible processes;
2. adverse effects are and remain below emission and immission limits;
3. after 25 years (one generation) no further intervention will be necessary;
4. maintenance, repair and replacement of any technical system as well as surveillance is technically feasible and secured by the necessary financial means;
5. social impacts are small (e.g. user restrictions or nuisances are properly compensated).

The question still remains: is it the polluter, who has to bear totally these costs? Or is it also a public affair to solve the problems immediately without transferring them, to the benefit of the public economy.

Comments to the author are very welcome!

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SUSTAINABLE REMEDIATION OF CONTAMINATED LAND - ECONOMICS OF REHABILITATION PROJECTS

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INTRODUCTION

Efficient economic management is specially important for the responsible of the rehabilitation of a polluted site with the objective to limit expenses and to make the best use of the money that is available.

This efficient management can be developed at every stage of a project: from the preliminary studies until the final rehabilitation works by means of the tools of classical economic calculation.

Optimization of the conception and realization of the evaluation studies, risk assessment, as well as, at the stage of the rehabilitation works, the permanent survey of cumulated and/or marginal costs, can participate efficiently to this objective of good economical management. However, the most important stage in the management of the project that may have usually the strongest financial impact is the choice of the rehabilitation technique specially because of the financial differences that are associated with the different solutions, mainly between immediate depollution and isolation or other techniques implying middle- or long-term maintenance and monitoring. In this situation, classical economic evaluation by the use of discounting calculations are very useful and may sometimes demonstrate that solutions that seem not expensive at the present time may be at the end a financial disaster.

A. ECONOMICS OF STUDIES AND RISK ASSESSMENT

The characterization of the pollution of a site and of its impact on human health and the environment can be realized by the means of different methods and tools: historical studies and specific evaluation based on various field investigations. The experience shows that an efficient economic management of these studies implies a rational and progressive use of these tools: from the most simple and less costly to the most complex and costly according to a multi-stage evaluation process that allows to solve the simple cases by a simplified study and to reserve the use of detailed and costly investigation to complex and difficult cases. In this objective, careful historical study taking in account all the useful information that may already exist (i.e. aerial photos, measurements in the surroundings of the site…) as well as the use of extensive investigation methods (like geophysics, soil gas measurements…) can be specially appropriate and if they are not sufficient, produce good basis for the planning of detailed and more costly investigations (boring, sampling and lab. analysis). More generally, a good coordination of the use of the different tools providing information to characterize a site and its impact is a condition of an efficient management at the stage of the preliminary studies.

Similarly, risk assessment that follows and that is the basis for the determination of the rehabilitation objectives can be efficiently managed by a progressive development. In simple cases, simple and low cost modelization inducing conservative estimation may be appropriate, specially if the result is the inexistence of significant risks or if the treatment of the pollution is easy to carry out at limited cost. On the contrary, deepened risk assessment based on complex modelization and the collection of numerous data in the field (both for emission and exposition) are adapted to important and complex cases, the underlying idea being that more money spent for detailed studies will reduce the cost of the rehabilitation project.

In a similar way, always in difficult and complex situations, the preliminary studies of characterization, risk assessment and determination of rehabilitation objectives should be completed by additional evaluations in the context of feasibility study of the rehabilitation project. If not, errors in the conception and/or realization of the rehabilitation works could induce important improductive expenses.

However, although more and more detailed studies may be seen as a guarantee of good projects, the money spent at this stage has to be limited. Consequently, there is an optimum between expenses for studies and expenses for works with an ideal objective to have a minimum for the sum of the two. However, this objective appears often to be an ideal difficult to reach!

B. ECONOMICS OF REHABILITATION WORKS

1. CHOICE OF TECHNIQUES

When dealing with the project of the rehabilitation of a polluted site for which the rehabilitation objectives have been determined, the first step to considerer is the choice of the remediation technique. The present basis of the decision-making procedure is to reduce risks to an acceptable level. In most cases, the realization of complete and short-term decontamination works compete with isolation measures that have to be coupled, in the middle- or long-term, with depollution systems such as pump and treat. From the economic point of view, these solutions have quite different implications. The first technique being generally much more costly at the time of its realization than the others that, however, induce expenses in the middle- or long-term.

Consequently, sound economical management requires a detailed and careful calculation of the final expense based on the initial cost but including also the expenses that will have to be done later for the solutions that are not definitive.

To allow the comparison, these expenses have to be given a present value by the use of a discount rate. Also to be considered, is the possibility to reuse (or not reuse or reuse with limitations) the site immediately after the works or later.

To explain these different possibilities and the associated economic calculations we have considered the classical example of a polluted site consisting of an underground polluting source (i.e. buried industrial waste) releasing pollution into groundwater used downstream, and we supposed that three solutions are possible to manage this pollution in order to avoid significant pollution downstream:

Solution 1: excavation and treatment of the source

Solution 2: isolation of the source

Solution 3: pumping and treatment of polluted water immediately downstream of the source.

The associated costs are:

Solution 1:

- immediate cost of the works: excavation and treatment of polluted material
- no further costs but income from the selling of the site for reuse.

Solution 2:

- immediate cost of the works: construction of the containment system, installation of drainage and treatment of leachate and/or gas, installation of a monitoring system
- maintenance of the site and operation of the collection and treatment of leachate
- maintenance and operation of the monitoring system
- repair/replacement of the collection and treatment system
- repair of the isolation system that will have to be reconstructed in the long-term
- no income from selling because no use possible (or very limited use).

Solution 3:

- immediate cost of the works: installation of the pumping and treatment system + monitoring system
- maintenance and operation of the pumping and treatment system
- maintenance and operation of the monitoring system
- repair/replacement of the equipments
- income from the selling of the land at the end of the depollution.

To illustrate this comparison, we have carried out a calculation as an example that is not a real case but that is based on figures considered as realistic by professionals. Discount rate chosen: 4%

Solution 1 : **Total cost : 60 MFF (9,15 M €)**
Selling of the land: 5 MFF
Final cost: 55 MFF (8,38 M €)

Solution 2 : **Life of isolation : 50 years**
Initial cost: 8 MFF (1,22 M €)
Final cost: 32 MFF (4,88 M €)

Solution 3 : **Time of operation : 25 years**
Initial cost: 4,4 MFF (0,67 M €)
Total cost: 44,17 MFF
Selling of the land: 1,87 MFF
Final cost: 42,3 MFF (6,45 M €)

One of the main conclusions of this comparison is that, although the result is depending on the hypothesis chosen and will be always strongly influenced by important uncertainties, the initial cost of a technique implying middle- or/and long-term expenses is far from representing the real final expenses to be made.

Residual Risks

In the case where a complete remediation project is achieved, no residual risks remain. On the contrary with isolation or middle-term depollution system residual risks for the environment and/or human health remain: indeed, although these solutions can be well conceived and realized, it is not possible to exclude a failure or a breakdown of the system (in the considered example: leakage inducing some pollution downstream).

The probability of such event can be estimated and taken in account. Also the responsible of the project may consider the possibility to manage this risk by the means of an insurance with, of course, an additional cost to be included in the calculation.

2. MANAGEMENT OF A DEPOLLUTION PROJECT

In the case of a rehabilitation based on depollution, the works can be managed according to the economical efficiency of the technique. For this, the responsible of the project can consider the evolution of the total cumulated cost or/and of the marginal cost, both of them versus the quantity of pollution extracted and treated.

The total cumulated cost is constantly increasing but with an initial starting point corresponding to a fixed initial cost (preparation, installation of the depollution yard) then an increase that is rather slow but growing more and more with the quantity of pollution treated (soil to be treated less and less polluted).

The marginal cost that is the money spent to treat one additional unit of quantity of pollution (i.e. cost of one kg of pollutants treated) is high at the beginning (incidence of the initial fixed cost) then decreases to a minimum that corresponds to the best yield of the treatment process, then increases again.

Consideration of these parameters gives the responsible who pays the possibility to estimate an acceptable economical limit for the depollution (limit depending on the technology used). If this limit is under the depollution objective fixed by the risk assessment, everything is O.K. If not, two possibilities may be considered:

- the use of another technique to finish the treatment: i.e. biological *in situ* depollution or monitored natural attenuation after excavation and thermal treatment,
- if the rehabilitation policy involves a fit for use decontamination objective, negotiation towards a less ambitious reuse more compatible with the performance of the treatment technique.