Discussion paper on:
Need for sustainable land management:
Role of a Risk assessment based approach
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NICOLE is a network for the stimulation, dissemination and exchange of knowledge about all aspects of industrially contaminated land. Its members from 17 European countries come from industrial companies (problem holders), service providers/technology developers, universities and independent research organisations (problem solvers) and governmental organisations (policy makers).

The network started in February 1996 as a concerted action under the 4th Framework Programme of the European Community. From February 1999 on NICOLE is self supporting and is financed by the fees of its members.

Photos:
TNO; SKB, the Netherlands; Corel.
1. Introduction

Risk based land management is considered by most EU member states as the best available strategy for dealing with the problems posed by land contamination (NICOLE Workshop Helsinki, May 2000). Significant progress has been made since the mid nineties leading to many countries now including the risk-based principle in their environmental policy on contaminated land.

The advantage of risk-based land management is that it is systematic and objective, and provides a consistent basis for dealing with uncertainties, making decisions, and convincing interested parties that appropriate action is being taken. Risk based land management relies on tools for assessing risk and managing risk, and as with all technologies, these techniques are developing and improving all the time.

Some stakeholders are concerned, however, that the tools available today may not be sufficiently developed and in the worst case may yield unsafe answers. This concern arises because risk assessments are influenced by uncertainty associated with data sets, assumptions and models. It is therefore important for all interested parties to work together to highlight the strengths and benefits of the approach, and identify any further work needed to resolve issues and address perceived weaknesses.

NICOLE, since its start in 1996, has been striving to provide technical support for a “Site Specific, Risk Assessment” based approach as the fundamental basis for sound management of contaminated land. This Discussion Paper has been prepared to provide constructive contribution to the debate and hopefully help readers to improve their understanding of the subject. The questions and answers on risk-based contaminated land management in Section 4 will help to clarify terminology and hopefully resolve doubts. We look forward to hearing your comments, suggestions and feedback on this paper. Please e-mail us at: m.euser@mep.tno.nl.
2. Background: Need for sustainable land management

2.1 General

As experience with managing contaminated land has grown, the perception of the problem has changed. In the early 1980s contaminated sites caught politicians and the general public by surprise. They were perceived as (a few) very severe incidents with poorly known but possibly disastrous consequences for human health and the environment. The perceived risks led to policies aimed at maximum risk control: pollution should be removed or contained completely. Today the contaminated land problem is no longer perceived as being restricted to a few severe incidents but as a widespread infra-structural problem of varying intensity and significance. Governments and industry are recognising that drastic risk control is usually unnecessary when taking into account the potential adverse effects of contamination for current and intended land uses and the environment. Moreover cleaning up all sites to background levels suitable for the most sensitive possible land use (the concept of “multi-functionality”), is not technically and financially feasible.

Experience shows that:
Remediating all soils and sediments by hard and fast technical means without considering the related side effects is not a viable solution. It is not wise to use only recent research results and to apply only innovative solutions. Much knowledge is already available, and in practice is often not sufficiently utilised. It is therefore important to disseminate the state-of-the-art knowledge and encourage widespread use of Risk Assessment and Risk Management tools.

There is still much to be done to develop sound management options which are technically and financially viable, and which take country-specific conditions into account.

2.2 A common understanding of three networks

In a Joint Statement, CLARINET and NICOLE presented the common view that risk-based approaches are vital to allow governments and industry to deal with contaminated land in a sustainable manner. Management strategies have to be further developed to deal with ecological aspects (impact of contaminated land on human health, water resources and other environmental receptors), economic aspects (relationship between soil-water contamination and sustainable land-use in urban and rural areas), spatial planning aspects (land-use changes).

Scientifically valid criteria for sustainable use of soil and groundwater in extensive remediation projects are needed to support the decision makers to find the right balance between contaminated land remediation and environmental protection. To this end NICOLE will work together with academics and with regulators.

2.3 Mission statement and deliverables of the new concerted action

The networks will work together to define best-practice of risk management for a variety of contaminated land situations, agreed by the different stakeholder groups. Spatial planning, socio-economic and other issues for integrative problem solving of contaminated land problems are taken into account, e.g. industrial sites still in use; urban Brownfield (including the city water problems); land, sediment and water interfaces, including river bed management; large area problems; groundwater resource management at a regional scale. The new initiative is aimed at identifying and developing cost-efficient remediation techniques and sustainable management options. Conclusions and recommendations will be provided to the European Commission for possible further consideration in future Framework Programmes.

One of the aims is to establish a knowledge base on “Sustainable Management Options” for contaminated land and to transfer the derived information to problem holders all over Europe to ensure efficient application of state-of-the-art. The sustainable management options will cover risk based management options. Fact sheets that describe the state of the current knowledge on all kind of instruments, technologies and tools will also be developed.

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2 CLARINET was a network of regulators and scientists focused on contaminated land rehabilitation under the 5th Framework Programme
3. Concept of risk based land management

This section explains the concepts that underpin Risk Assessment and Risk Based Land Management. It should be read in conjunction with Section 4 (Questions and Answers on Risk Based Land Management).

**Risk assessment:**
- Is concerned with defining the potential consequence of an activity and defining the probability that this consequence could occur (refer to Figure 1).

**Risk based land management:**
- Means applying the established techniques of risk assessment and risk management, to address problems associated with land contamination. This includes the actions we take to keep risks within tolerable limits.

The following example illustrates risk assessment and risk management.

**An example**
Assessing risks is something that we all do in our everyday lives as a matter of course. For example when deciding if it is safe to cross the road, we take into account factors such as traffic speed, the type of vehicle (whether a truck or bicycle), visibility, the condition of the road surface, the road width, and our ability to cross the road. What in effect we are in doing is assessing the likelihood (the probability) of there not being enough time to cross the road safely, knowing the outcome (the consequence) of being hit by a passing vehicle.

Although such assessments are no more than simple informal considerations based on experience and common sense, the process is the same as that used in more complicated assessments of risk. In such situations a more rigorous, formalised, objective and systematic procedure is used to identify and assess risks. This process is known as risk assessment and involves defining both the potential consequence of an activity and the probability of it occurring. It is a well-established technique and is commonly used in the design of buildings, bridges, offshore structures, cars and aeroplanes. It is also used in other aspects of our lives such as setting standards for safe drinking water and food.

Having identified and evaluated risks, the next step is to decide whether or not the risk is acceptable and whether mitigation measures are required. This is a subjective process requiring value judgements to be made. In the example above, before making a decision on whether to cross the road, we would think about how much of a safety margin we need to avoid a near miss. This will depend on factors such as how cautious we are, the scope we have for crossing faster if our estimate of the traffic speed is incorrect, and how urgently we need to cross the road. We may conclude that it is not safe to cross the road at this location and walk to traffic lights or a pedestrian crossing. In other words we manage the risk taking into account the prevailing circumstances.

An alternative strategy might be for an authority responsible for road safety to commission a study to look at the worst case scenario, i.e. traffic travelling at the speed limit, thick fog, a slippery road surface and a pedestrian with a broken leg on crutches carrying a heavy suitcase. An estimate of the time needed to cross the road safely could then be made and this increased by a factor of say 100 to account for traffic exceeding the speed limit, and/or having faulty brakes etc. Regulations could then be passed requiring all pedestrians not to cross the road unless this amount of time is available to make the crossing. Clearly, this would be nonsense. However, when carrying out risk assessments it is therefore important to ensure that the same lack of logic is not applied to other situations which are more complex or emotive and not as easy to understand.

Risk management is therefore about determining courses of action to mitigate identified risks for specific circumstances, taking into account factors such as the severity of the consequence, the ability to recover from the consequence, the likelihood of success, and the benefit.

In this way, the risks to health or environment, which are associated with the contamination, can be understood. It also ensures that the responses are designed to manage and reduce these risks. Without this risk assessment process, it will be difficult to establish if remedial strategies are benefiting the community or the environment, and as a result, it is uncertain whether or not valuable resources are being allocated to the right issues. Risk reduction is not always proportional to the amount of time, effort or money put into a problem.
4. Questions and answers on risk based land management

Q1: How long has risk assessment been used for contaminated land?

A1: Risk based decision-making is not a new concept. The 1983 US report “Risk Assessment in the Federal Government”, published by the National Research Council and the National Academy of Sciences, established the principles of risk-based decision-making. In fact risk-based (though very conservative) analyses have been used world-wide to set for example safe levels of exposure to industrial chemicals, since the 1940s. A risk based decision-making process for remediation is now the norm across EU Member States (CLARINET and NICOLE, 1998). It is widely supported by environmental regulators and it forms the basis for a site specific “fit for purpose” approach to land affected by contamination.

Q2: How is the risk assessment process applied to contaminated land?

A2: Contaminated land risk assessments are usually based on the source-pathway-receptor concept. This is a site assessor’s interpretation of the way a contaminant is likely to migrate to a receptor from the source through various environmental media, e.g. air, soil and water, and how the receptor may become exposed to the contamination, taking into account site specific characteristics. An example of a conceptual model is shown in figure 2. Here the source is contaminated soil, the receptors are humans and the aquatic eco-system, and potential pathways include the ground through which dissolved contaminants in groundwater migrate to the watercourse and vapours migrate into the house. Potential human exposure routes are ingestion of contaminated soil, inhalation of vapours and contaminated dust, and dermal contact with contaminated soil. For a pollutant linkage to be viable there has to be a source of harmful contamination, a receptor, a pathway and a means of exposure. The sensitivity of all receptors and the viability of potential pathways are not equal. For example a hard covered industrial site will represent a less sensitive pathway/receptor combination than a residential house with a garden. Consideration of the potential pathways and receptors at conceptual model stage can have a significant influence on the priority assigned to the identification of potential sources.

Figure 2. Human Exposure (pathways) to soil pollutants
Viable pollutant linkages are identified by carrying out a systematic review of hazards that may be associated with a site considering both the existing or proposed use of the site and its environmental setting. The objective is to produce a qualitative understanding of the potential for the site to present a risk; highlight those sources of risk that will require detailed assessment; and enable an assessor to discount those sources as not requiring further assessment.

If the linkage is viable, its significance is determined by first calculating, or where practical measuring, exposures and comparing with accepted (safe) exposure levels. An accepted safe threshold is derived from consideration of the harmful nature of the chemical, e.g., its toxicity, and the risk it poses taking into account site specific conditions. It is sometimes useful to think of it as a speed limit for vehicles. The speed limit represents a balance between the risk of injury and the need to maintain acceptable journey times. In other words, if the traffic were limited to 5 km/hr there would be far less accidents and injuries but the traffic system would grind to a halt with an adverse impact on the quality of life, the economy and so on. Similarly, all chemicals produce harmful effects if the dose is high enough (even water is harmful if consumed to excess). The safe threshold represents a balance between the risk of an adverse effect, and the excessive cost of eliminating all pollutants from the environment.

Where the exposure is found to be unacceptable, risk management responses are required.

Q3: How reliable are the assumptions and data used for Risk Assessments?

A3: Risk assessments require data on contaminant levels, the nature of the land and the type of receptors, and they require the use of different types of models to predict the way contaminants will move in the environment, how much exposure could occur, and what are the ‘safe’ levels of exposure. Therefore, at each stage of the process, uncertainties may be introduced. However, the risk assessment process should be designed to cope with uncertainty. Safety factors or conservative assumptions are built into the process to ensure that the risk assessments tend to over-predict potential risks rather than under-predict them. For example, the potential consequence of exposure to contamination is measured by a chemical’s toxicity. When determining the safe exposure levels for chemicals, the concentrations identified as safe in laboratory experiments, are usually reduced by safety factors of 100 - 10,000.

Similarly, if models are used to describe the behaviour of contaminants in the environment, they are based on established principles and they have been verified by field or laboratory experimental data either in Europe, the USA, or elsewhere. Models from other countries can be successfully applied in other locations as long as it is confirmed that all the assumptions are still relevant. Sensitivity analysis can be applied to identify which parameters have the greatest impact so that these can be measured more accurately.

Q4: Is Risk Assessment used as an excuse for no actions or limited actions?

A4: Responsible problem holders use a risk-based approach as the most sound, structured and safe solution for sustainable land management. The aim is to reduce risks to protect receptors. Both problem owners and authorities nowadays recognise the fact that by spending money on the real problems, the net benefit to the environment is greater. Risk assessment is also a useful tool for setting priorities and helping stakeholders to allocate public and private resources wisely.
Q5: Would fixed standards not be a better approach, as everyone would understand them?

A5: Fixed standards for soil clean-up can be set in a number of ways:
(1) Through generic risk assessment designed to be protective in all cases
(2) By using current analytical detection levels
(3) Set at natural or background levels.

None of these strategies necessarily works. The first is usually over-protective and conservative since these values are designed to be used at all sites, including the worst case; the second is arbitrary and not designed to protect health and would change constantly as detection technologies improve; and the third may be either over-protective or under-protective, depending on the natural levels of different chemicals in the area. So although fixed standards are easy to apply, they will not necessarily create greater benefits for the environment, and they can result in valuable resources being applied to sites which do not present any risks. In addition, it is often not technically feasible to remove all contaminants to background or detection levels. Aside from the unnecessary expense, removing all contamination from the soil or groundwater can often require excessive use of energy (fuel) and may involve a different type of damage to the environment.

The cost of clean-up usually increases exponentially as the clean-up levels decrease. Therefore, the incremental benefits need to be reconsidered: e.g. is it better to spend more money on one problem or spend it elsewhere to reduce risks.

Apart from it being unachievable, expensive and sometimes even damaging to the environment it is usually not the best strategy to remediate a site according to fixed standards. Generic risk-based standards should be used in the screening phase in a tiered risk assessment process. In the subsequent assessment phase, site-specific levels are designed to address potential exposure conditions which exist at the site according to its specific use and environmental conditions. This is the most effective approach. A useful analogy is that one would expect a hospital operating theatre to be cleaner than one’s kitchen, which in turn one would expect to be cleaner than one’s garage, although all three would be fit for purpose.

Q6: There are many models in use, why is there not a standard to which everyone can refer? And do results depend on the adopted model?

A6: Indeed many models are available to deal with all the different aspects of risk assessment including determining toxicity, contaminant migration in air, soil and water, and exposure concentrations. It is difficult to set one risk assessment standard, because situations vary from site to site, and Member States may set specific national or local requirements. In addition, models are always improving as they incorporate greater flexibility and reduce conservatism. However, experience has shown that when different models are applied to the same solution, the results are comparable. It is very important that any model results are presented in such a way that the underlying assumptions are made transparent, and that experienced practitioners run them. In any case the computer models must not be used as black boxes. Nevertheless, it is important to emphasize here that the methodology, as presented in this Discussion Paper, is a generic one.
Q7: In a contaminated land risk assessment how are mixtures of chemicals dealt with?

A7: During the course of a contaminated land risk assessment, a risk assessor will make an assessment of the hazardous effects of the contaminants by reviewing available toxicity data including dose – effects (response) relationships and considering the reliability and applicability of the data. The assessment will also consider whether intake of a contaminant via different exposure routes is additive. It is often conservatively assumed that this is the case and a total body burden approach adopted. Where exposure to more than one contaminant is possible, an assessment is also made as to whether the effects are additive and whether synergism or antagonism is possible.

Q8: Is a quantitative risk assessment always necessary to demonstrate that a site is fit for purpose?

A8: No, not always. If an exposure assessment has shown that there are no pathways currently completed, or likely to be complete in the future, a quantitative risk assessment is not necessary. In addition, to avoid unnecessary expenditure of time and money, it is a wise strategy to use a tiered approach. Such an approach usually starts with a comparison of a limited number of data with risk based screening or look-up levels. The uncertainty is compensated for by the built-in conservatism. If considered necessary, more quantitative data can be obtained in a next stage for a more detailed, risk assessment. This approach has been widely used. An example is the approach which is often referred to as RBCA (Risk Based Corrective Action or ‘Rebecca’). Most other models encompass the same principle.

Q9: What are the remedial options in a risk based approach?

A9: The purpose of remediation is often to reduce risk, and risk is controlled by limiting exposure. An effective strategy therefore is often to block the pathways by applying intervention measures, such as installing active barriers. Other remedial options may consist of source control (total or partial removal), directly shielding the receptors from exposure or any combination of these measures. There are of course other reasons for carrying out remediation such as compliance with corporate policy or preference, to increase land value, or a commercial agreement entered into during a divestment.
Q10: **What stakeholders should be involved?**

*A10:* A variety of stakeholders may play varying and different roles in contaminated land decision-making. Risk assessment and risk management decisions therefore need to be made in consultation with a variety of affected and interested people like land owners/problem holders, site users, neighbours, community, regulators and planning authorities and not to forget the consultants/contractors involved in designing and implementing the remediation. It is therefore important to identify all of the key stakeholders in the decision-making process at an early stage (e.g. even for decisions about what data should be acquired). Involving a large number of stakeholders in decision-making will add to the costs, complexity and duration of decision-making. However, wide and early involvement may save future difficulties caused by disagreements, and will also add to the value of the overall solutions.

Q11: **How will stakeholders benefit from risk assessment?**

*A11:* The use of risk assessment in decision making on contaminated land will lead to an improved allocation of resources, which will allow better and more productive use of land. There are still many Brownfields today, lying derelict and unproductive because clean-up is unachievable since target levels of residual contamination have been set unrealistically, without any consideration of fit for purpose and related acceptable risks. As a consequence either suitable remedial technologies needed to achieve such low clean-up levels are not available or the cost of remediation is not compatible with any economically sustainable activity. The same considerations apply to productive sites with contaminated groundwater. Groundwater quality objectives should be defined according to a time frame, to present and potential use of the resource and to site specific conditions. By consideration of these principles the use of risk assessment can help return Brownfields to beneficial and productive uses sooner. The sustainable reuse of these former industrial areas will become available for homes, businesses and leisure areas, etc. at a viable cost to society. This will also reduce the pressure on Greenfield sites. The result will be a safe and attractive environment.
Q12: Where can I get more information?

A12: Useful web-sites:
- www.CLARINET.at: Contaminated Land Rehabilitation Network For Environmental Technologies in Europe
- www.NICOLE.org: NICOLE is the principal forum that European business uses to develop and influence the state of the art in contaminated land management in Europe
- www.RBCA.org: Risk based corrective action framework
- www.eea.eu.int: European Environmental Agency information and access to European Environmental agencies
- www.EPA-CLU-IN: Gateway to web based information on contaminated land in the USA, operated for the US EPA Technology Innovation Office

More literature:
- CARACAS and NICOLE joint statement ‘Towards a better future’, October 1997
- CARACAS book: Risk assessment to contaminated sites in Europe, vol. 1 (Scientific basis) and 2 (Policy Framework), 1999
- NICOLE/CLARINET/ETCA/SENSPOL ‘Management of contaminated land for the protection of water resources’, September 2000
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