Water Resource Protection Issues in Relation to Contaminated Land

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Abstract

European countries are facing significant contamination of groundwater resources caused by former industrial activities. Nevertheless, European countries have different legislative and technical approaches to the problems of groundwater protection and land contamination. Some of these different approaches are based on differences in legislation; some are based on the differing local perspectives on the importance of groundwater. Four important issues have been identified:

- *regulatory approaches (technical and procedural) between water resources and contaminated land;*
- *the influence of the Water Framework Directive in groundwater and contaminated land remediation;*
- *the point of compliance for both protection and remediation of groundwater resources (at the water table, the site boundary or the receptor);*
- *the acceptance of natural attenuation in remediation.*

Similarities and differences will be outlined in this paper.

Keywords: contaminated land, groundwater, pollution, remediation, natural attenuation, regulation, Europe

INTRODUCTION

Although technical specialists (such as hydrogeologists, hydrologists and soil scientists) speak a common language and share a common understanding of the science of the subsurface environment, European countries have different legislative and procedural approaches to the problems of groundwater protection and remediation of groundwater contamination. Some of these are based on the differences in legislation in different countries, some on the differing local perspectives on the importance of groundwater; some consider groundwater and soil together – in either protective or remedial measures, others consider them separately. These differences can hinder discussion in international fora as participants may have different concepts about the issues and therefore it can often be difficult to come to any consensus because of this lack of understanding. The Working Group 3 of CLARINET (Contaminated Land and its impact on Water Resources) therefore set out to try and get a little more common understanding of each others issues by seeing how much difference there really is, and how much commonality. At the same time we wanted to tease out the really important issues. The work builds on a study carried out for the Danish Environmental Protection Agency in preparation for the 4th meeting of the Ad Hoc International Working Group on Contaminated Land in Copenhagen (June 1999).

Questionnaires were sent to all CLARINET participants about many aspects of water resources management, groundwater protection and remediation. We were interested in understanding the main reasons behind any differences in the various countries' approaches. The use of a case study approach to bring out the details in a more practical way was considered but time and resources were against us producing anything of detail. We were also aware of the ConSoil 2000 Case Study[1] which covered in some part the legislative background and the groundwater issues. So a very limited conceptual model was used at a late stage to bring out some differences between where we establish the

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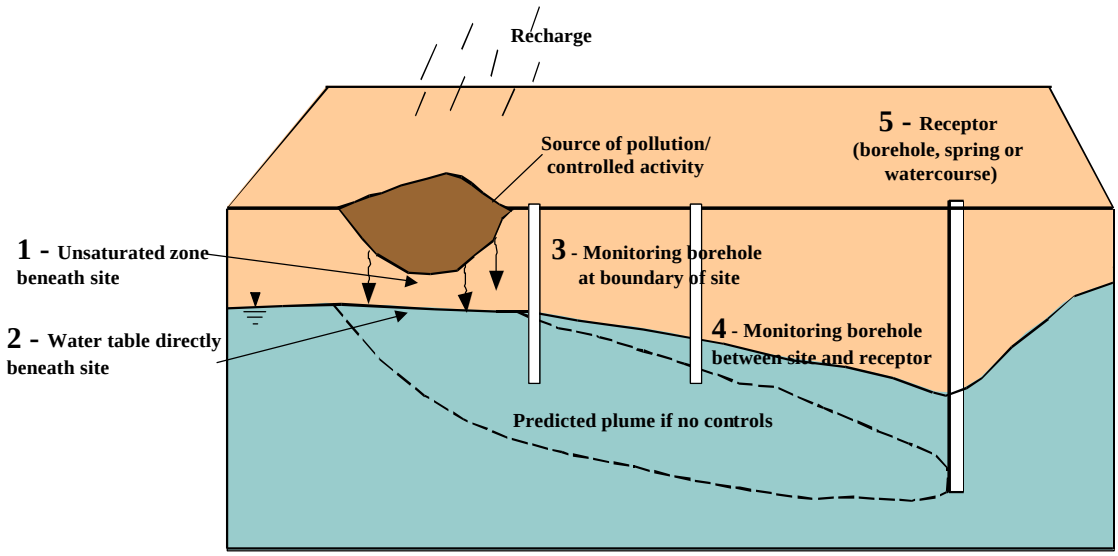

Figure 1 Conceptual cross-section through a site with a variety of potential compliance points for the protection of groundwater, and the setting of remedial targets.

receptor and compliance point when protecting groundwater from pollution and remediating it once it has been polluted.

Countries were also asked to identify the main types and sources of contamination in groundwater in order to clarify the type and extent of their problems. These will be listed in the final report from CLARINET but are essentially very similar throughout all countries. Thus solvents, hydrocarbons, gasworks derived contamination and heavy metals are ubiquitous as significant pollutants of groundwater. There was some debate as to whether the remit of the group should have been widened to include diffuse source pollutants, since many countries consider agriculturally derived nitrate as their major problem for groundwater quality. However, we limited the scope to industrially derived point source pollution, to keep the study within manageable proportions. The identified problems were then compared against the R&D needs identified elsewhere in CLARINET to help inform the priorities for FP5.

1. The ConSoil 2000 Case Study centred on an area of the Bitterfeld District of Saxony-Anhalt in Germany. Here long-term industrial pollution has resulted in widespread pollution of soils, river sediments and groundwater with a variety of industrial chemical by-products. Teams from four countries prepared an outline study of how they would deal with the problems of remediation from their own legislative and procedural perspectives. These studies together with a description of the area and an appraisal of the reports is presented in a supplement to the proceedings of ConSoil 2000.

A small sub-set of the respondees met at the CLARINET plenary sessions as a working group. In the Helsinki meeting of May 2000 we reviewed the synopsis of the questionnaire, which had been collated by Dominique Darmendrail. There are many issues which could be identified and analysed from the data but given the minimum of resources that we could allocate to this it was decided to focus on some key aspects. A fuller analysis of these will form the main substance of the Water Resources section of the final CLARINET report.

Four key issues were identified. These are to consider similarities and differences in countries approaches to:

- regulatory approaches (technical and procedural) between water resources and contaminated land;
- the future influence of the Water Framework Directive in groundwater and contaminated land remediation;
- the point of compliance for both protection and remediation of groundwater resources (at the water table, the site boundary or the receptor);
- the acceptance of natural attenuation (NA) in remediation.

To clarify some of these issues a supplementary questionnaire, which included additional questions about the Water Framework Directive and a conceptual diagram (Figure 1) showing a cross-section through a site with a variety of potential compliance points for

protecting groundwater and setting remedial targets, was sent out in June. Data from this exercise is still being collected. This paper outlines the findings to date.

Technical and procedural differences of approach between water resources and contaminated land

Most countries tend to have legislation that has developed separately in relation to the management of water resources and the protection/remediation of contaminated land. Water legislation invariably predates that on contaminated land and often the requirements of the former drive actions on the latter, particularly with regard to targets (e.g. Austria, France, Ireland, UK). Thus water protection is an important factor in consideration of contaminated land impacts in all countries. Some countries are still developing specific legislation and policies on contaminated land (e.g. Greece, Ireland) while those countries that have a longer history of dealing with soil and water pollution issues have integrated the two areas (e.g. Denmark, Finland, The Netherlands, Switzerland).

There is significant variability in the responsible decision-making bodies for contaminated land management and water management between countries. Most have a tiered system of regulatory control. With the exception of Belgium, legislation and overall policies are set at the national level. Some countries regulate the major polluting industries/activities at the national level (e.g. Norway, UK) but regulation is usually devolved to local authorities. These are often organised into two or three tiers (e.g. regional, prefectural, municipal). A few countries base their water management organisations on hydrological catchments (e.g. France, UK) which are not necessarily co-incident with political boundaries. The role of environmental protection agencies (EPAs) or their equivalents is also variable. It ranges from where the EPA is a national body, but with local responsibility for management of the water environment and the regulation of some contaminated land remediation (UK), to where Regional EPAs only provide the technical support to the local authorities who implement/enforce the regulations (Italy).

For those countries that have a high strategic reliance on groundwater for water supply, groundwater is the primary receptor of concern when dealing with contaminated land (e.g. Austria, Denmark, Germany). The reliance on groundwater for public supply is variable regionally both within Europe and individual countries and is clearly related to the geographical distribution of aquifers. Hence the importance of groundwater in local decision-making may also vary. All countries consider water resources in general (groundwater and surface water) to be a main target. Most countries seem to distinguish between higher levels of protection needed in relation to abstractions as opposed to groundwater resources in general. Although some countries (e.g. Germany) adopt a precautionary approach towards groundwater in principle, in practice account is taken of the local circumstances. In others (e.g. UK) the main approach is based around site-specific risk assessment within framework guidance on the protection of groundwater resources.

The future influence of the European Water Framework Directive

The Water Framework Directive, although under development for some time was finally agreed in June 2000. It is designed to prevent further deterioration, and to protect and enhance the quality and quantity, of aquatic ecosystems. By doing so it also contributes to the provision of water supply in the quantities and qualities needed for sustainable development. Its key objectives include:

- the focusing of environmental water policy on water as it flows naturally through river basins towards the sea;
- consideration of both surface and groundwater, taking into account the natural qualitative and quantitative interactions between them;
- the objective of achieving good status of all waters within 15 years of adoption of the Directive and;
- the designation of ‘protected areas’ with special requirements.

Those countries that have been more closely involved with its development are most clearly aware of its implications. Some have already developed legislation that mirrors the Directive (e.g. Italy). Others are still considering the content.

Most countries that have an opinion consider that the Directive will have some influence over contaminated land remediation, but not a substantial one. The influence will be in relation to the interaction between land, groundwater and surface waters. It thus requires an understanding of the geochemical and pollutant fluxes that perhaps does not exist at present for most river catchment systems.

The Directive is likely to be most influential in urban catchments. As the impact of point source discharges on surface water quality diminishes due to action by regulatory bodies, the problems of diffuse pollution will come more to the fore. Further improvements in river water quality and the achievement of ecological quality objectives will only come about if the diffuse impacts can be identified, quantified and prioritised for action. This will require local authorities and regulatory bodies to understand the influence of

historically contaminated land within urban areas on the underlying groundwater, and the influence of groundwater discharges on river systems. Where the latter is significant, particularly at times of low flow when surface run-off is low, then the requirement for river quality improvement will need to relate back to the land and the associated groundwater. Hence for those countries with large industrialised urban areas the Water Framework Directive may well be a significant driver for remediation.

The point of compliance for both protection and remediation of groundwater resources

All countries involved in the CLARINET project have specific policies and laws for the prevention and the protection of water resources. They have developed specific technical approaches for groundwater quality protection and groundwater quality remediation in relation to contaminated land sites. In general risk assessment procedures or recommendations are used, often those that are elaborated within contaminated land management frameworks. They integrate three main assessments: fitness for use, protection of the environment, and reduction of aftercare.

The main principles that underlie the risk assessment approach to water resources in the European countries are:

- definition of the sustainability of the resources;
- prevention of new pollution;
- remediation of past pollution where this is necessary to protect the environment or water users.

The following comments are based on answers from Denmark, France, Germany, Ireland, Italy, Norway, Switzerland and the UK who used a conceptual model illustrated in Figure 1 as an aid to describing their approach in a potentially real situation.

When faced with contaminated water resources, contaminated land stakeholders, and in some countries water supply managers, have specific choices depending on the circumstances. In relation with new activities that may be potentially polluting, groundwater protection is enforced:

- at the surface of soil (Denmark, France, Ireland, Switzerland for all kind of activities, Germany for waste disposals);
- at a monitoring borehole at or near the boundary of the site in Italy (unless more conservative measures, at the water table immediately below the site, are required by the public bodies);
- on a site-specific approach in Norway (no specific rule in this country).
- at the water table for List I substances in the UK where the groundwater is a strategic resource, otherwise on a site-specific basis, taking account of the risks to groundwater resources and interconnected surface waters.

The behaviour of stakeholders when facing historical contamination of groundwater varies from country to country:

Denmark

If historical contamination indicates that it is impossible to identify the responsible polluter then limited public funds are used to remediate the contaminated sites according to priorities. The target in relation to groundwater protection is the groundwater resource itself and when the resource is protected then existing and future wells will be protected too. A step by step risk assessment is used to determine if soil contamination has to be remediated. At step 1 the groundwater criterion has to be satisfied immediately below the site and in step 2 and 3 the groundwater criterion has to be satisfied at a distance equal to one-year's groundwater travel, up to a maximum of 100 metres down-gradient.

France

The exposure point taken into account in the detailed risk assessment for groundwater resources varies depending on the particular situation:

- at the water table immediately below the source of pollution in the case of uncontaminated aquifers,
- at the receptor when the aquifer is contaminated on a large scale but is still potentially usable;
- at or near the boundary of the site of the activity when the aquifer is contaminated but needs to be preserved as a drinking water supply resource.

Except for the first situation, the choice of exposure point taken into account in the risk assessment for water resources has to be discussed by the different partners (local authorities, those responsible for the site, drinking water supply providers, etc.).

Germany

The compliance point can vary depending on the situation. It is usually at the water table immediately below the site, or at a monitoring borehole at, or near, the boundary of the site, but can be a monitoring borehole between the site and the receptor.

Ireland

The setting of remediation targets for groundwater in Ireland is dependent on the type of contaminant present in the soil and groundwater and is based on the risk based corrective action (RBCA) approach. In the case

of a gasworks site the contaminants in the soils are either removed or treated such that they do not pose a significant risk to groundwater. The groundwater itself is treated in some cases and target values are set for the discharge to sewer and also for the groundwater at the boundary of the facility. Another example would be the accidental or historic discharge of chlorinated solvents into groundwater. In this case the remediation target would be set at the receptor, as one of the remediation technologies that is effective for this type of contaminant is monitored natural attenuation.

Switzerland
Generally, the targets for remediating groundwater from any kind of pollution are set at a monitoring zone at or near the boundary of the site of the activity (zone in the immediate downstream of the site in question). In certain cases where groundwater pollution caused by a specific site has already reached a receptor, such as a drinking water well, this point of compliance has also to be taken into consideration. This is because the Swiss legislation requires that no public drinking water supply wells should be affected by pollutants derived from a contaminated site. In such cases the remediation of groundwater has to take place to ensure that no pollutants will affect the wells in question in the future as well as meeting certain standards in the groundwater immediately downgradient of the contaminated site.

United Kingdom
In the UK, each circumstance is considered on a site-specific basis. Remedial targets are set using a tiered risk assessment tool which considers the receptors and the natural processes of attenuation which may act on the pollution. The compliance point varies according to the importance of the groundwater:

- strategic drinking-water source – groundwater at or near site boundary (unless adopting NA is cost beneficial when the compliance point can be extended to the receptor);
- non-strategic but locally important – at the point of abstraction;
- where it is in continuity with surface waters – at the surface water receptor.

Conclusions
The observed differences seem dependent on national policies. An in-depth analysis will be conducted during the following months for the final CLARINET report.

Acceptance of NA in remediation
General agreement between CLARINET members is that NA is a process that occurs naturally under specific conditions. The conditions depend upon the nature of the contaminants (in particular their aptitude to be attenuated) as well on site conditions. Therefore the US EPA definition is considered an acceptable starting point:

> *Naturally occurring processes in soil and groundwater environments that act without human intervention to reduce mass, toxicity, mobility, volume or concentration of contaminants in those media. The* in situ *processes include: dispersion, dilution, volatilisation, adsorption and chemical or biological stabilisation or destruction of contaminants.*

Countries have different points of view when considering NA as a remedial technology. NA is not acceptable in most countries as an overall remedial panacea but has to be applied on a site-specific basis where the evidence can be substantiated. The 'three lines of evidence' approach is generally being adopted by countries who have developed or are developing guidance or protocols (The Netherlands, UK and Germany):

- documented loss of contaminants (for shrinking plumes);
- an indication that biodegradation is actually realised in the field (for shrinking or stable plumes);
- laboratory assays showing that microorganisms in site samples have the potential to transform contamination under expected site conditions (or use modelling to predict results).

In other countries the approach is more cautious, with acceptance by the general public being a perceived difficulty.

Most countries consider from a policy point of view that NA should solely relate to mass or toxicity reduction (e.g. Austria, Finland, France, Germany, The Netherlands, and UK). Dilution is generally not accepted but in practice it is difficult to separate it from the other factors. Policies have to face this reality in order to be applicable and in the UK, for example, dilution can be taken into account for remedial target setting but not as a justification for NA itself. Thus it can play a role as a potential option within a risk-based setting.

Boundaries to the use of NA as a remedial process have to be defined for the different countries. These limits have either to be given under consideration of a range of aspects such as:

- geographical scale (within the site boundaries?);
- time-scale (30 or 50 years to achieve the remedial goals within a sustainable context?);
- attributes of affected aquifers (those not currently considered as strategic or irreplaceable?);

- characteristics and behaviour of contaminants and breakdown products (authorised for substances which can be attenuated – based on existing case studies or experiences?);
- existence of sensitive receptors (drinking water supplies for example);
- age of the pollution (restricted to historical pollution?).

Only The Netherlands and the UK have published a methodology for assessing NA, although Germany has one in preparation. Other countries are currently reflecting on the best acceptable approach. Most authorities are still considerably sceptical and reserved with regard to the controlled use of NA processes for the remediation of water (and soil) pollution related to contaminated sites. This is certainly due to the limitations of national experience of NA. NA case studies have been registered and studied in only a few countries (Belgium (Flanders), Denmark, Germany and UK).

All countries consider that monitoring of NA has to be planned in order to demonstrate in the longer term that NA is continuing and will lead to the remedial objectives as defined in the risk assessment performed on the site. More active, additional treatment may need to be adopted and contingency plans implemented if NA is not seen to be appropriate or effective.

Any extension of this approach seems to need additional research and effective discussion between the authorities and responsible parties in relation to contaminated sites.

CONCLUSIONS

It is clear that different countries approach groundwater protection and the remediation of contaminated groundwater in slightly differing ways. These do not seem to be due to any differences in the problems faced or the understanding of the basic hydrogeological processes. They are more related to cultural differences or differing perspectives on the importance of groundwater as a source of drinking water. Some of them may well be important in the long run. For example there is clearly no uniformity yet in the adoption of NA as a remedial technique across Europe. Reluctance by some countries to accept NA may be partly because they wish to understand the science more but it may also be because they have a more inflexible approach to groundwater protection or that they place the compliance point closer to the pollutant source. The final CLARINET report will attempt to elucidate some of these matters in more detail.