DEVELOPMENT AND IMPLEMENTATION OF SOIL QUALITY AND CLEANUP CRITERIA FOR CONTAMINATED SITES¹

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1. ABSTRACT

A critical but vexing problem with contaminated land has always been assessing the significance of contamination and the degree of cleanup required for contaminated soils and sediments. Various approaches have evolved to address this difficult issue and debate continues over which is the most appropriate. With the growing number of contaminated sites, the majority of which are non-catastrophic, interest in criteria-based approaches has grown. While there are difficulties associated with the development and implementation of generic criteria, they serve a definite purpose in an overall program for contaminated land management their usage is gaining favor in a growing number of jurisdictions around the world.

2. INTRODUCTION

Land contaminated by toxic and hazardous substances is a critical environmental problem facing nations throughout the world. Central to its resolution is the development and implementation of policies and procedures for assessment of the significance of contamination and the extent of cleanup required at a particular site.

As a Visiting Scientist in Norway during 1988-1989, this author conducted an international study to identify approaches used for establishing cleanup goals for contaminated land and the technologies employed to achieve those goals [1]. The information derived was to assist the Norwegian government in the development and implementation of a newly evolving program for assessment and cleanup of contaminated land. A key aspect of this study concerned the attitudes toward and use of "predetermined standards, guidelines and criteria" (hereinafter referred to simply as criteria) for contaminated soils. The policies and procedures used in ten nations were reviewed including the United States, Canada, England, The Netherlands, West Germany, France, Denmark, Sweden, Finland and Norway. Information was derived from published literature, personal inquiries and site visits. Subsequent to that study, further consideration of this topic has continued back in the USA. This paper presents an overview of approaches for establishing cleanup goals at contaminated sites and discusses the purpose and scope of generic criteria and their use around the world.

3. OVERVIEW OF APPROACHES USED TO ESTABLISH CLEANUP CRITERIA

Approaches to establishing cleanup criteria for contaminated land vary widely between and within nations (Table 1) [1-5]. In few cases is there explicit, uniform national guidance.

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Table 1. Approaches to establishing cleanup criteria for contaminated sites and use of soil quality and cleanup criteria [after 1].

Nation	Approaches to Establishing Cleanup Criteria
<u>North America</u>	<p><i>United States:</i> For NPL sites (i.e. Superfund) use applicable, relevant and appropriate federal and state requirements where available and formalized site-specific risk assessment methodologies. For non-NPL sites, procedures vary widely by State and government jurisdiction and include multiples of generic criteria and background levels as well as site-specific formalized risk assessment methodologies. [3,10,11,25]</p> <p><i>Canada:</i> Only Quebec has a formalized approach where a comprehensive list of generic criteria adapted from the "Dutch List" is used for initial guidance and screening with site-specific risk assessments used as appropriate. Environment Canada is sponsoring development of national criteria during 1990. [3,17,18]</p>
<u>Western Europe</u>	<p><i>England:</i> No national system. National agency guidance on "Trigger Concentrations" for some contaminants routinely found on industrial sites commonly considered for redevelopment (e.g. old gas works). [12,26]</p> <p><i>The Netherlands:</i> National policy of maintaining soil "multi-functionality". Generic criteria (A-B-C levels) for evaluating significance of pollution enacted in 1983 (often referred to as the "Dutch List"). Reference values for good soil quality (new A-level) enacted in 1987. Contaminated land must be cleaned up to multi-functional quality (A-level) unless it is shown to be technically or financially unfeasible or environmentally harmful. [6,7,9,13-16]</p> <p><i>West Germany:</i> No national approach, control by provincial governments (Lander). Use of "Dutch List" with consideration given to local conditions. West German "Guides/Threshold" values for soil contamination under development based on soil protection policy initiated in 1985. [8,20,27]</p> <p><i>France:</i> No national approach, control by local governments. Use qualitative risk assessments. If pollution by natural substances, must reference background. Development of standards for soil pollution now under consideration. [19,20]</p>
<u>Scandinavia</u>	<p><i>Denmark:</i> No national approach, control by local governments. Use "Dutch List" for general guidance and screening as well as existing Danish standards where available. Final decision on particular site based on site-specific considerations. Formalized risk assessment methods under development. [21,28]</p> <p><i>Sweden:</i> No national approach. Limited experience to date. Use generic criteria (e.g. "Dutch List") if available for initial guidance but site specific decision based on local factors including technical, political, economic and psychological. [22]</p> <p><i>Finland:</i> No national approach. Limited experience to date. Use generic criteria (e.g. "Dutch List") for initial guidance. [23,29]</p> <p><i>Norway:</i> No national approach. Limited experience to date. Use generic criteria (e.g. "Dutch List") if available for initial guidance. Site-specific decision based on intended site use, technical feasibility and cost as well as secondary contamination during cleanup. [24]</p>

¹ Information gathered during fall 1988 to spring 1989.

non-systematic process which is affected by diverse factors such as: 1) the type of site and contamination, 2) applicable existing standards and criteria, 3) governing laws and regulations, 4) site ownership, and 5) public attention and perceptions. It is not uncommon that cleanup goals in the form of acceptable residual contaminant concentrations are never explicitly set. In these cases an acceptable course of action for remediation is agreed upon, the results of which yield a de facto cleanup goal. Where cleanup goals are explicitly set, various approaches have been used, including: 1) ad hoc site negotiation and decision making, 2) cleanup to background levels, 3) application of predetermined standards, guidelines and criteria, 4) site-specific mathematical modeling, risk assessments and risk management decisions, or 5) a combination of the above.

There has been considerable discussion and debate over which approach to establishing cleanup goals is the "best approach". One aspect of this debate has centered around the establishment and application of predetermined standards, guidelines and criteria (hereinafter referred to simply as criteria).

4. DEVELOPMENT AND IMPLEMENTATION OF SOIL QUALITY CRITERIA

4.1 Purpose and Scope for Numerical Criteria

Numerical criteria are essentially generic contaminant concentrations which can readily be applied to a given site or problem to enable preliminary if not final assessment of the issue at hand. Numerical criteria are needed for various purposes, including 1) to enable an initial assessment of the significance of contamination at a particular site, (e.g. how "dirty" is the site) 2) to guide the cleanup operations as they occur (e.g. how much soil should be excavated), 3) to provide a reference for determination if cleanup has been effectively conducted, 4) to provide a basis for evaluating the performance of contaminated soil treatment plants and 5) to assess the appropriate reuse of contaminated soils following treatment.

Intimately connected to the criteria themselves are numerous issues regarding data management and interpretation. For contaminated sites, equally important are the sampling design, analysis and interpretation used to generate the database to which the criteria will be applied. While standard laboratory analyses of physical and chemical properties are often involved, there is a growing need for criteria based on field portable instrumentation and devices which yield real-time data. This is useful to guide investigation activities (e.g. soil boring and testpit sampling) and valuable during site remediation (e.g. to guide contaminated soil excavation).

4.2 Status of Use of Soil Quality and Cleanup Criteria

Soil quality and cleanup criteria are in use or being advocated by an increasing number of people, institutions and regulatory agencies [1-4]. Interest has been growing due to the increasing number of contaminated sites in many nations and the realization that complicated site specific assessments physically cannot be accomplished and generic criteria are needed to streamline the site cleanup process. The features of several lists of criteria in use around the world are highlighted in Table 2 while further discussion follows.

Individuals confronted with decision-making regarding a contaminated site commonly express the desire and need for soil quality criteria specific to contaminated land [1]. Readily available, comprehensive criteria were viewed as essential to facilitating initial site review and screening.

Table 2. Features of selected listings of criteria for contaminated sites [after 1].

Characteristic	The Netherlands	Quebec, Canada	Ontario, Canada	Great Britain
Agency Responsible for Development	Federal Ministry of Housing, Physical Planning and Environment	Provincial Ministry of the Environment	Provincial Ministry of the Environment	Federal Department of the Environment
Date Adopted	1983, 1987	1988	1984	1983, 1987
Common Name	"Dutch List"	-	-	"Trigger Values"
Legal Standards	No	No	No	No
Contaminants Considered	12 metals 7 inorganics 25 organics 7 other	14 metals 12 inorganics 65 organics 3 other	18 metals 1 inorganic 1 organic	10 metals 6 inorganics 2 organics
Contamination Guidance Levels Considered	3	3	1	2
Media Considered	Soil Ground Water	Soil Ground Water	Soil	Soil
Soil Properties Considered	None	None	Limited	None
Land Uses Considered	None	None	Agriculture Residences & parkland Commercial & industrial	Gardens & Allotments Parks & play fields
Data Quality Requirements	None specified	None specified	None specified	Some specified
Action if Exceedance	Investigate and/or cleanup	Investigate and/or cleanup	Not specified	Cleanup or change land use

There are demands for unequivocal cleanup criteria, often put forth by owners, developers and future users of contaminated land. Equally evident, however, was a strong appreciation for the difficulties and potential problems of developing and implementing criteria and the belief that there must be site-by-site flexibility in setting final cleanup goals.

The first nation to establish a national, comprehensive set of criteria for contaminated land was The Netherlands. In 1983 a national act was promulgated which put forth the concept of "multi-functionality" for soil and included criteria for assessing the significance of soil and ground water contamination and guiding site assessment and cleanup ("Dutch List"). In support of a broad soil protection policy, reference values were recently enacted for a "good soil quality". These criteria were never intended to be standards, but rather guideline values for deciding upon the necessity for carrying out (further) investigations and risk assessments. In practice however, the criteria have been implemented as if they were in fact standards, in parts of The Netherlands and elsewhere. The Netherlands has now used this approach for more than 5 years to remediate several hundred sites.

The use of comprehensive numerical criteria appears to be gaining favor in many other nations, especially for use in preliminary assessment of the significance of contamination and the potential extent of cleanup. In 1988, the province of Quebec, Canada promulgated a comprehensive list of criteria, based in large part on the "Dutch List". The Canadian government has recently initiated a project to establish national criteria for Canada. Establishment of similar criteria lists is also under consideration in other jurisdictions (e.g. West Germany, France).

Other national and provincial government agencies have also established criteria in the form of acceptable limits for soil contaminants. While far less comprehensive than the Dutch or Quebec lists, they are intended to serve as guidance in site assessment and cleanup. Some of the lists are focused to common contaminated sites (e.g. leaking underground gasoline tanks or coal gasification plants). In many cases the criteria are dependent on the proposed land use (e.g. Table 2).

In most every case, soil quality and cleanup criteria are not legal standards. Rather they are guidance criteria intended to be used with due consideration of site specific factors. The exceptions seem to be for a few notorious substances such as polychlorinated biphenyls (PCBs), some polycyclic aromatic hydrocarbons (PAHs) and dioxins.

Even in those jurisdictions where criteria have not been formulated specifically for cleanup of contaminated land, reference is commonly made to existing criteria, such as the Dutch List (Table 1). There is also direct use or adaptation of existing national or international standards, often developed under programs and legislation unrelated to contaminated land. Examples include drinking water standards, ambient water quality standards, storm water runoff limits, limits on sewage sludge application to agricultural lands, occupational air quality standards, ambient air quality standards, and so forth. Notably, in several instances, ground water quality standards have been set roughly equivalent to drinking water standards (e.g. Wisconsin, USA, Denmark, The Netherlands). In some cases, reference to existing standards has been formally incorporated into a waste site cleanup program (e.g. USA Superfund program).

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5. DISCUSSION

It is apparent that there are numerous potential advantages and disadvantages associated with the development and use of soil quality and cleanup criteria for contaminated sites (Table 3). Criteria-based approaches are not claimed to be the "best" approach for addressing contaminated sites, but rather a necessary part of an overall program for dealing with contaminated land. Numerical criteria also facilitate national or regional soil protection programs and encourage redevelopment efforts for contaminated land.

Development and implementation of scientifically well-founded yet workable and accepted criteria specific to contaminated land is a challenge to be sure. Soil quality criteria should ideally account for many factors, including inherent hazards, site characteristics (transport and fate, exposures), environmental and health risks, capabilities of monitoring and cleanup technologies, resource limitations and institutional constraints. The intended land use(s) is becoming a widely accepted part of the criteria development and implementation process. Criteria should be established at a federal level if possible and be consistent with existing standards and criteria and all relevant laws and regulations.

In developing a list of criteria, generic risk assessments made for a range of representative contaminated sites and situations can be used to yield a range of criteria targets. From this target range, a "reasonable" set of criteria could then be promulgated under the oversight of a respected panel of experts representing all affected groups including technical, political,

Table 3. Example advantages and disadvantages to the development and implementation of soil quality and cleanup criteria.

<u>Advantages</u>
<ul style="list-style-type: none">o Speed and ease of implementation.o Similar sites would be handled in a similar manner.o Useful for initial assessment of significance of contamination.o A priori information facilitates planning and action.o Encourages developers to undertake decontamination and restoration.o Potential consistency with strategies for environmental standards.o Reality of contaminated land made easy for layman.o Facilitate environmental audits of industrial sites.o Facilitates monitoring/permitting of operational industrial sites.o Can be used for performance assessments of soil treatment plants.o Implies non-negotiability and reduces local political influences.
<u>Disadvantages</u>
<ul style="list-style-type: none">o Some key site-specific considerations can often not be accounted for.o Standards, guidelines and criteria are not formulated for many toxic substances of concern. Existing standards formulated under other programs are not necessarily appropriate for contaminated land.o Generic values imply a level of understanding, knowledge and confidence which likely does not exist.o Once values are established, site-specific flexibility may be difficult.

socioeconomic, legal and citizenry forces. In developing a comprehensive listing, efforts should be made to prioritize the contaminants to be included with due consideration of the most common contaminants as well as the most toxic, persistent and mobile.

Whatever criteria are promulgated, there should be some information given regarding environmental monitoring methodologies and data interpretation. The criteria should allow sufficient flexibility to account for relevant site-specific factors and trigger a comprehensive risk assessment if needed. Finally, the criteria listing should be periodically reviewed and revised to incorporate the ever-expanding knowledge base in this area.

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