Research & Development Highlights

Technical Series
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Evaluation of Site-specific Risk Assessment for Contaminated Lands

Introduction

Human health risk assessment is becoming a common tool for improving risk management decisions in the redevelopment of contaminated sites. This growing application has lead to an increase in the number of risk assessment practitioners, the number of projects being performed and the number and variety of techniques and models being used. As a result, there is considerable variation in risk assessment practices. Theoretically, this could result in significant variation in risk estimates for one site when performed by different practitioners. This uncertainty may have considerable implications on land value, business decisions and expenditures associated with remediation of contaminated sites. Therefore, an effort to characterize and understand this variability may help in harmonizing risk management processes across the country.

Research Program

Golder Associates Ltd. (Golder) was retained by Canada Mortgage and Housing Corporation to design and conduct a study examining the current practices and associated variability amongst practitioners of contaminated sites risk assessment in Canada. The study was performed in two phases. The first phase consisted of a survey distributed to both private and regulatory sector practitioners. A questionnaire distributed to private firms addressed details on their risk assessment procedures, technical capabilities and experience. A survey distributed to regulatory practitioners provided insight on regulator experience and acceptance of human health risk assessment of contaminated sites.

The second phase explored the differing techniques used amongst human health risk assessment practitioners by employing a round robin risk assessment of a hypothetical contaminated site. The case study was developed by Golder to re-create real world problems concerning exposure analysis, exposure assessment, toxicity assessment and risk estimation. The scenario consisted of a residential housing development proposed on former industrial lands. Nine firms, selected by geographical location and assessment experience, were asked to do a screening level human health risk assessment on the hypothetical site. Although there were no "right" answers, analysis of the participants' results enabled the identification of variability and sources of uncertainty existing amongst practitioners.

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Findings

Results for Phase I of the study revealed that Canadian risk assessment practitioners have broad in-house expertise in relevant disciplines such as environmental engineering, toxicology, chemistry, biology and hydrogeology; and often supplement their own expertise with hired consultants. Most of the firms handle a variety of carcinogenic and non-carcinogenic chemicals, and can evaluate, design, and implement risk management or remedial strategies for their removal. Many firms have experience in modeling the fate of contaminants in soil gas, groundwater, fugitive dust and air; although there are a significant number and variety of environmental fate models being employed. The regulatory survey indicated that governmental agencies support the use of human health risk assessments in the management of contaminated sites but currently do not provide formal regulation for its application.

Ultimately, any risk assessment must determine if a chemicals presence will pose a risk to human health. For risk to exist the following basic elements must be present:

- the presence of a chemical at a potentially hazardous concentration;
- a mechanism of release to the environment;
- an exposure pathway through or in environmental media, such as air, soil, surface water, groundwater, or biota;
- a route of uptake, such as inhalation, transdermal absorption or ingestion; and
- a receptor, in this case humans, that can be exposed to the potentially hazardous chemical.

To evaluate risk, chemical concentrations at a site are either measured directly from the relevant medium or they are modeled. The effect of chemicals at potentially hazardous concentrations and how they influence the receptor requires an understanding of toxic potency, carcinogenicity and dose; as well as an understanding of receptor characteristics such as body weight, age and surface area exposed. In addition, all potential pathways for the contaminant to travel and routes of uptake by the receptor must be considered. With the degree of speculation required in interpreting some of these elements, risk assessments have a built in component of uncertainty associated with them. However, the magnitude of the uncertainty is largely governed by the assumptions imposed by the assessor. The purpose of conducting a round robin risk assessment was to try and identify the extent of this uncertainty.

As anticipated, the round robin portion of the study revealed significant variability in the way the participating firms performed human health risk assessments, and significant variation in risk estimate values for various chemical exposure pathways - risk estimates ranged over several orders of magnitude. To determine the sources of variation, Golder performed a systematic breakdown of the procedures used by the participants, where each stage of their analysis was examined for variability. Analysis of the work presented by each participant was divided into three stages. The first stage examined the exposure pathways identified and assessed, as well as the type of quantitative analysis performed. The second stage examined the sources of variability in receptor characteristics and variability in contaminant concentrations in exposure medium. The third stage focused on the models that were used and the uncertainty introduced by the models for predicting chemical concentrations in exposure medium.

This procedural analysis identified four major causes for variability between participants. These were:

- differences in assumptions made about chemical toxicity;
- differences in receptor characteristics used;
- the use of different model types and assumptions for the prediction of vapour and dust concentrations in air;

- and differences in assumed exposure pathways which were or were not considered relevant to the scenario.

The study provided a basis for comparing variability amongst risk assessors under screening level risk assessment conditions rather than detailed conditions. A detailed evaluation would likely result in less variation amongst practitioners, as a result of more realistic exposure assumptions and a little less conservatism. That is not to say however, that the conclusions drawn from the study are not entirely applicable to more detailed risk assessments; in fact, some of the conclusions may reasonably apply. The following is a presentation of the conclusions cited in the report:

1. The type and number of pathways included in the risk assessments varied between participants. For trace metals in surface soils, oral ingestion was the most commonly included pathway. Fugitive dust inhalation and consumption of domestically grown produce were assessed included/excluded by various participants.

2. Highly divergent risk estimates were demonstrated for all contaminants and exposure pathways. While general agreement existed amongst the acceptability of the risks, the divergence suggest lack of agreement could prevail if soil contaminant concentrations were appropriate.

3. The variability in risk estimates was primarily explained by variability in dose estimates. Thus, for improved conformity amongst assessors, both of these elements should be considered.

4. Variability in dose estimates via direct pathways (soil ingestion and dermal contact) were primarily explained by receptor characteristics. Variability in dose estimates for complex indirect pathways (dust inhalation and indoor gas inhalation) was primarily explained by model uncertainty, which affected the predicted exposure concentration.

5. Correlation amongst the various determinants of dose suggest assessors are applying conservatism to several variables. This suggests the need to re-visit the approach to applying conservatism, to avoid overly conservative risk assessments and uncertainty.

6. Models used to predict wind generated dust emissions are highly dependent on input parameters such as soil type, vegetative cover and size of the site. Therefore, it is important for screening-level risk assessments to use appropriated site-specific data.

7. Models used to predict soil gas fate and transport are highly dependent on the model assumptions, and site-specific parameters such as depth to contamination, soil properties (porosity, permeability and organic carbon content) and building characteristics (concrete cracks, drains and building underpressurization).

Recommendations

Screening level estimates are supposed to provide a reasonable conservative estimate of the upper limits of health risk for a given situation. When screening risk estimates do suggest a substantial risk to human health, the study recommends that risk management decisions should be made only after more detailed assessments are conducted. It also recommends that all contaminated sites human health risk estimates be expressed as a possible range of values (a reasonable maximum and minimum) and possibly with some aspect of probability associated with this range based on the assumptions employed. This would generate a better understanding of the health risks for both risk assessors and risk managers, and better consequent risk management decisions.

A summary report was produced as an alternative to the full, detailed report. Both are available from CHIC.

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Research Report: *Evaluation of Site-Specific Risk Assessment for Contaminated Lands*

Research Consultant: *Golder Associates Ltd.*

A full report on this research project is available from the Canadian Housing Information Centre at the address below.

Housing Research at CMHC

Under Part IX of the National Housing Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic, and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research.

This factsheet is one of a series intended to inform you of the nature and scope of CMHC's technical research program.