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GROUND INVESTIGATION GUIDELINE
7.2 - Contaminated Land Management

INTRODUCTION

The need for contaminated land investigations has increased in recent times due to the growing real estate and infrastructure development opportunities in Hong Kong. As an extension to the AGS Publication on *Ground Investigation Guidelines* (*7.1 – Land Contamination Investigation*), the current guideline is intended to introduce the backgrounds and applications of the Hong Kong Risk-based Remediation Goals (RBRGs) that can be used to compare soil and groundwater qualities against concentration limits that are protective of human health. It should be noted that while other eco-toxicity impacts can be considered in defining remediation goals, the primary consideration is still human health risks. Therefore, the focus on this guideline will likewise concentrate around human health considerations.

CONTAMINATED LAND

Contaminated land can be caused by a variety of events including spillage, leakage, disposal of toxic chemicals to the ground and/or groundwater. Examples of such events in Hong Kong could be from petrol stations, fuel storage facilities, shipyards or car repair / dismantling workshops.

Historically in Hong Kong, contamination has been defined by a set of clean-up standards from the Dutch Soil and Groundwater Protection Act (specifically, the Dutch B levels). This is, of course, not entirely suitable as the considerations used in deriving the Dutch B levels were for the Netherlands and not Hong Kong (for example, groundwater represents approximately 65% of the Netherland's drinking water source while it is virtually 0% in Hong Kong).

To increase the applicability of the Hong Kong contaminated land standard, a locally-derived standard was developed and has been gradually implemented since August 2007 (*http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/files/gme.pdf*). Assumptions used include typical Hong Kong soil and groundwater conditions, meteorological conditions and land uses. This standard involves a risk-based approach which considers not only the concentration of a potential contaminant and its toxicity, but also the likelihood of which exposure (by a human receptor) to this contaminant can be expected. The resultant RBRGs thus presents threshold contaminant concentrations, below which hazards or risks to human health arising from exposure to the contaminated soil and/or groundwater are considered minimal. Where concentrations are above the RBRGs, clean-up will be required.

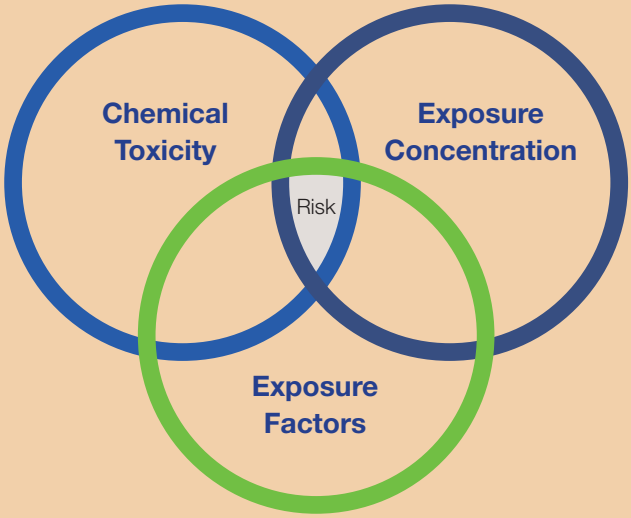
RBRGs DEVELOPMENT PROCESS

With use of conceptual site models (CSMs), RBRGs can be developed by considering a "source-pathway-receptor" approach. This assessment can broadly be expressed quantitatively as:

Risk = Exposure Concentration x Exposure Factor x Chemical Toxicity

where,
Risk = level of health risk acceptable to public
Exposure Concentration = chemical concentration that human receptors are exposed to (i.e., RBRGs)
Exposure Factors = chemical exposure via pathway
Chemical Toxicity = level of toxicity of chemical

This may also be schematically represented below.



This schematic shows that "risk" is a factor of the 3 components (toxicity, receptor and exposure). An example could be that in the case of a landfill site, a "toxin" exists in the form of wastes, a "receptor" is present in the form of nearby public, but if adequate capping and protective measures can be engineered, the "exposure pathway" can be controlled and hence, the risk can be managed. If a major crack occurred in the landfill capping / lining however, then an exposure pathway is created and thus a health risk is created.

The development of the overall risk model consists of the following key steps and considerations:

- Identify the chemicals of concern (COCs), of which 54 have been developed on the basis that they are known to occur in the Hong Kong environment.
- Define the land use type, of which 4 different land use scenarios (urban residential, rural residential, industrial and public parks) reflecting the typical physical Hong Kong setting has been used.
- Identification of exposure pathways through soil or groundwater, including ingestion, dermal contact, particulates and volatile gases.

From the above considerations, likely exposure pathways based on typical Hong Kong land uses are shown in Table 1. RBRGs in terms of contaminant concentrations can then be estimated by additionally considering:

- toxicity in terms of toxicity indices through one or more exposure routes; and
- the presence of non-aqueous phase liquids (NAPLs) which may remain as long-term sources of "concentrated" (undiluted) contamination.

By combining all the considerations, Risk-Based Remediation Goal Tables (RBRGs for Soil and Soil Saturation Limits and RBRGs for Groundwater and Solubility Limits) are developed as a remediation standard in Hong Kong and can be found in the Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management in the Hong Kong Environmental Protection Department website (*http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/files/gme.pdf*). In each table, the COCs are listed against the RBRGs in the relevant land categories, therefore, the engineer may use the tables to compare the detected concentration of COCs in the soil and/or groundwater obtained from the site to the concentration limits of the relevant land use categories before making any decisions for further actions.

However, users of RBRGs must be aware that RBRGs are derived with the assumptions of common environmental conditions, human activities as well as exposure pathways in Hong Kong. Some circumstances and exposure pathways may not be considered during the derivation of RBRGs, such as:

- Domestic use of groundwater (i.e., drinking and irrigation) which is extracted from the site or the locations near the site without any treatment.
- Re-development of contaminated land for agricultural or nature conservation purposes.
- Protection of landscaping plants in the public park which is re-developed from a contaminated site.
- CSMs for unusual circumstances and ecological receptors.

In addition to the potential impact of contaminants to human health by direct exposure via soil and groundwater, other exposure pathways and COCs may exist which are not directly covered by the RBRGs. This is demonstrated in Figure 1, where exposure pathways such as vapour intrusion and food chain uptake / bioaccumulation may also impact human health.

Therefore, in thoroughly understanding the potential health impacts of contaminated land, the RBRGs are good standards to provide a risk assessment under typical conditions. Practitioners, however, must recognize the limitations of the RBRGs and as needed, consider additional risks that may not be adequately covered by the RBRGs.

Table 1. Exposure pathways in each relevant land use category (Source: Guidance Manual for Use of Risk-based Remediation Goals for Contaminated Land Management - *http://www.epd.gov.hk/epd/english/environmentinhk/waste/guide_ref/files/gme.pdf*).

	Types of RBRG	Soil					Groundwater
	Pathway	Ingestion	Dermal contact	Volatiles	Particulates from surface	Subsurface volatiles indoor	Volatiles indoor
Land Use Scenario	Urban Residential	✓	✓	✓	✓	✓	✓
	Rural Residential	✓	✓	✓	✓	✓	✓
	Industrial	✓	✓	✓	✓	✓	✓
	Public Parks	✓	✓	✓	✓		

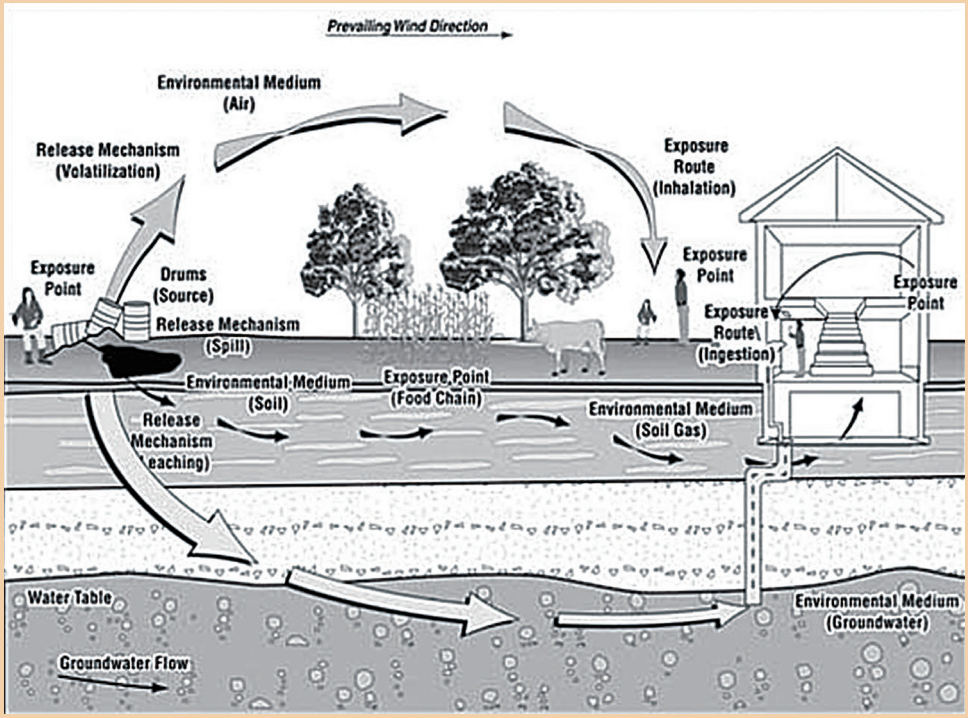


Figure 1 Site Conceptual Model of Potential Exposure Pathway (Source: Agency for Toxic Substances and Disease Registry - http://www.atsdr.cdc.gov/hac/phamanual/ch6.html)