

STRATEGIES FOR CONTAMINATED SITE REHABILITATION IN SOUTH EAST ASIA

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SYNOPSIS

Over the last decade South East Asian countries such as Malaysia have taken steps to protect their natural resources. These initiatives have included the establishment of environmental legislation to control hazardous wastes and industrial or municipal discharges. While this legislation will clearly strengthen existing and future pollution controls, contamination resulting from previous environmental policies have left an urgent need for the development of guidelines or criteria to assess the significance of contaminated sites and to prioritise problem sites for rehabilitation.

Contamination assessment criteria is currently being considered by a number of countries around the world. Generally two concepts have emerged in practise, one using an established set of guidelines for all sites and the other based on site specific factors. Each approach has found acceptance, but there is growing recognition to improve these concepts in terms of their practicality and site specificity.

This communication presents a case history of a contaminated site investigation and rehabilitation feasibility study conducted at a site located on the Island of Borneo. This study was designed and implemented using a contamination assessment approach which incorporates established guidelines and hazard assessment based on site specific exposure pathways. This hybrid approach of contamination assessment criteria combines the benefits of guidelines and hazard assessment, promoting effective project planning and better recognition of site specific issues.

INTRODUCTION

The last few decades have seen the rapid industrialisation of developing countries in South East Asia such as Malaysia. Unfortunately, this rapid growth has produced unwanted side effects including the contamination of atmospheric and terrestrial environments. In spite of domestic pressures and intense economic growth, the authority responsible for environmental matters in Malaysia, the Department of Environment, has made substantial progress towards the management and control of hazardous wastes and effluent discharges.

Environmental legislation concerning the control of sewage and industrial effluent has been in place in Malaysia since 1979. In 1989, the Department of Environment promulgated legislation for the generation, handling and disposal of hazardous

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wastes (Awang 1991). Justifiably, the bulk of this environmental legislation has been intended for the management of industrial and municipal waste sources based on the "end of the pipe" pollution management philosophy for pollution prevention. Other issues however, such as the assessment of contaminated land have not yet been addressed.

CHARACTERISTICS OF CONTAMINATION AND CONTAMINATED SITES

Environmental contamination can occur in a wide variety of ways, however in Malaysia, as in many countries, there is no clear definition of what comprises contamination or for what constitutes contaminated land. Traditionally, the presence of chemical substances or biological pathogens in soil, water, air, plants or animals have been used to identify and establish a site as *contaminated* and the agents responsible as *contaminants*. The significance of the contamination is generally related to the (known or suspected) adverse affect caused by the contaminants on human health or the environment and the concentrations in which they are found.

ASSESSMENT CRITERIA

In many countries, including western nations, there is continued debate over what constitutes appropriate criteria for the assessment of contamination and contaminated land. In remediation programmes the question of "how clean is clean" becomes especially difficult to answer in situations where high public or private expenditure is at stake, human health is at risk, or when public concern is pre-eminent. At the heart of the debate over contamination assessment is whether contaminated sites should be evaluated using a set of guidelines common for environmental quality or evaluate each site based on site-specific factors (SAHC, 1991).

GUIDELINES APPROACH

The criteria or guideline approach involves the direct adoption or adaptation of existing contamination criteria in light of site specific criteria. Typically, these criteria are associated with land use requirements (residential, industrial, agricultural) and include values for contaminants present in background or pristine settings and contaminant concentrations to be used as a threshold to initiate further investigation. Some guideline, such as those published by the Netherlands Government, also include a contaminant value which may require a site to be rehabilitated (MHP&EN 1983).

The guideline approach is probably the most common approach used for the assessment of contaminated land and is currently being used by a number of countries around the world including the United Kingdom, Canada, and Australia (ANZECC & NHMRC 1992; Richardson 1987; SAHC 1991).

Typical benefits of using guidelines include:

- Provision of absolute values to select site rehabilitation goals.
- A list of potential contaminants with a range of concentrations.
- Criteria which is applicable to all sites.

- Minimise site assessment costs.
- Rapid decision making for site rehabilitation.

In general, most published lists of guidelines or criteria tend to focus on the acceptable contaminant concentrations with the intended general land-use not on site specific circumstances. In some cases the guidelines are too conservative, in others not conservative enough.

HAZARD ASSESSMENT APPROACH

Another approach used to assess the significant of contaminated land involves a risk or hazard assessment of potential adverse affects to human health or the environment. A critical component of this type of site-specific evaluation is the baseline risk assessment. The baseline risk assessment documents the magnitude of human and environmental risk from a particular site and the primary causes of that risk. The baseline risk assessment is used to determine the need for an immediate action to remove contamination, define goals for site rehabilitation, or even to support the decision for no action at all ("no-action alternative"). The baseline risk assessment can be used to produce criteria which is protective of human health and the environment for all substances and for all exposure pathway combinations considered. Land usage is considered in the assessment, but in an indirect manner to estimate the magnitude, frequency, and routes of exposure.

This site specific approach has the advantage that only sites which are proven risks are rehabilitated. The principal drawbacks of the risk or hazard-based approach lie in the limited availability of reliable toxicity data, the amount and cost of generating the data required, and the time needed to produce the assessment.

COMBINED APPROACH

A third method of contaminated land assessment involves using both the contaminant guidelines and the hazard assessment. In brief, the guideline values are used to define the initial scope and data quality requirements for a site assessment. Depending on the land use requirements, guidelines for industrial sites are used as an initial threshold for rehabilitation and preliminary remediation design. A hazard or risk assessment is incorporated early on to evaluate potential exposure scenarios on a site-specific basis and update the data used for decision making. This hybrid approach of guidelines and hazard assessment is currently being used by some regulatory programs in the United States to prioritise potentially contaminated sites for further investigation and to help define clean-up goals for sites which are being rehabilitated. This approach is able to capitalise on the advantages to minimise the disadvantages of the two philosophies discussed previously.

CASE HISTORY

In spring of 1991, a field investigation was completed by Golder Associates of a former waste disposal area located on the Island of Borneo. The field programme was intended to determine the nature and the distribution of contaminants present in

the former disposal area. Although the current use of the land was primarily industrial, the land could ultimately include residential use. A review of relevant regional environmental criteria found very little information to determine acceptable levels of contaminants in soil regardless of land use. As a result, an assessment method was developed involving both contaminant guidelines and hazard assessment techniques to provide the scope of the field sampling and analysis programme and ultimately the need for and extent of site rehabilitation.

SITE BACKGROUND

The former waste disposal site is located in a general use and industrial use area. The disposal site shared a common boundary with a shadow waterway which ultimately drains to the South China Sea approximately 1 km north of the site. The area encompassing the disposal site was believed to have been a sand mine which was later filled with waste materials. The adjacent waterway is within a coastal belt and is part of a major regional river system separating a peat swamp forest from the coastline.

The native soils of the site consist of fine silty sand and some silty clay. The depth to groundwater ranged from 0.03 - 0.6 m below ground surface, depending on local rainfall events and tidal changes. Most of the wastes in the disposal area were in contact with the shallow groundwater. The net groundwater flow from the site was toward the adjacent waterway.

The types of wastes within the site and associated contaminants were generally unknown, however the presence of containers with pesticide residues, including diel-drin, endrin, and DDT, were suspected in the disposal area. In some portions of the disposal area metal containers were exposed at the surface, but most of the area had been regraded with a soil cover.

CRITERIA SELECTION

In order to provide an initial scope of testing for the field sampling programme, soil and groundwater quality guidelines were selected based on criteria published by the Netherlands Government under the Soil Clean-up Act of 1983 (so-called Dutch Guidelines). The Dutch Guidelines were selected based on their wide spread application and acceptance in Europe and Australasia and the similarity of parameters (pesticides, etc) to those potential contaminants in the disposal area (MHP&EN 1983).

The Dutch Guidelines relate contamination concentration to three levels as follows:

- A Level Nominal Background (generally detection limits for organics)
- B Level Level above which further investigation may be required
- C Level Level above which remediation may be required

In order to incorporate site specific factors and to evaluate potential contaminant pathways, a hazard assessment was conducted on contaminants with concentration, HAZPAC 91, p.69-73.

STRATEGIES FOR CONTAMINATED

trations found in excess of the Dutch C Level for soil and groundwater.

FIELD INVESTIGATION

Scope of Field Programme

The field investigation programme for the disposal area included geophysics, soil sampling (surface and subsurface), groundwater sampling, surface water and waterway sediment sampling. Analytical testing parameters were those included in the 7 groups of contaminants of the Dutch Guidelines. Sample quantitation limits were set at the Dutch B Level. The identification and quantification of contaminants from the "Other Pollutants" category listed in the Dutch Guidelines was accomplished using analytical techniques employing gas chromatography and mass spectrometric detection.

Summary of Results

The principal contaminants found in the disposal area were heavy metals and petroleum hydrocarbons (C₁₅-C₃₆). This narrow range of contaminants was attributed somewhat to the age of the disposal area (approximately 30 to 40 years) and the strong tidal flow and drainage of the waterway to the coastal receiving waters. The sediments adjacent to the waterway were found to be relatively unaffected by the disposal area.

The salient conclusions available from the field and analytical programme were as follows:

- Groundwater was found to be characteristic of an estuarine environment with no evidence of site related contamination.
- Soil samples collected from "background" or pristine locations had concentrations of naturally occurring hydrocarbons in excess of Dutch B level for petroleum hydrocarbons, between A Level and B Levels for metals.
- Several soil samples showed contaminant concentrations in excess of Dutch B Levels for metals and hydrocarbons.
- Petroleum hydrocarbons and zinc were the only contaminants found in excess of Dutch C Levels.

The potential for elevated concentrations of petroleum hydrocarbons in samples collected from "background" locations was taken into account in the formulation of assessment criteria, as the region was known to have surface and near surface petrochemical resources.

DECISION ANALYSIS

The logic diagram for the contamination assessment of the disposal area is shown below in Fig. 1. The decision analysis process was developed with input contributed by all parties involved, in consideration of the overall goals of the site

rehabilitation programme. Using this decision analysis scheme, results from disposal area samples were compared with established background area results and Dutch C Levels. As mentioned previously, the region encompassing the disposal area was known to have natural sources of petroleum hydrocarbons, therefore it was critical to establish background concentrations of hydrocarbons (primarily C₁₅-C₃₆) and other constituents for comparison with site related concentrations. Those portions of the disposal area which showed contaminant concentrations in excess of Dutch C Levels were evaluated further using a site specific hazard assessment. The hazard assessment was designed to assess the risk of exposure of contaminants (in excess of Level C) to humans based on the site being redeveloped for more sensitive land uses than general industrial.

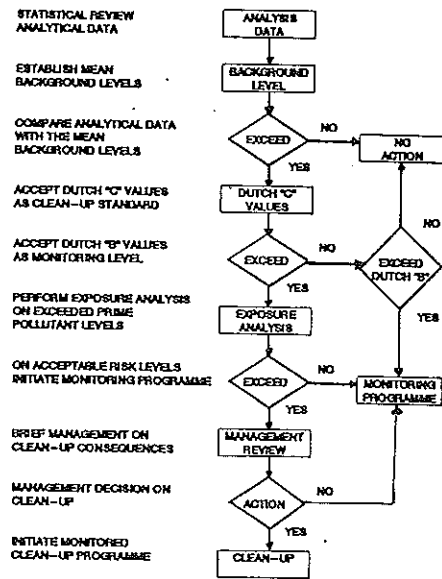


Fig. 1 Logic Diagram for Contamination Assessment

RELATIVE BENEFITS

This combined guideline and hazard assessment approach to contaminated land assessment allowed a rapid evaluation of potentially contaminated areas of the disposal site, and where necessary, site related hazards were judged on site specific factors and exposure scenarios. The benefits of using this type of assessment approach include:

- Clear definition in project planning and project goals
- Cost effectiveness regarding data requirements

- Allows flexibility through updating information (Monitoring Programme)
- Narrows the scope of possible contaminants for consideration

SUMMARY

As Malaysia and other South East Asian countries emerge from their phase of intense industrialisation there is an urgent need to establish clear concise goals to address the significance of contaminated land.

The rehabilitation of contaminated sites to "background" levels fails to make environmental and economic sense for most situations. Criteria based assessment is simple, rapid to implement, and eliminates the need for vast amounts of data, yet the wholesale adoption of contamination assessment guidelines from other countries can produce unrealistic objectives. Site specific hazard assessments are the preferred method of contaminated site evaluation, but they require time and data requirements in excess of criteria based assessment.

One approach to consider is a comprise of these strategies. The hybrid approach of guidelines and hazard assessment presented in the case history was rapid to implement, was not unusually data-intensive, but still considered site specific factors. Improvements of this hybrid assessment approach are underway to develop (regional) assessment criteria for soil, groundwater, surface waters and sediments based on established risk assessment models. In time, these risk-based criteria will replace the guideline levels providing a better and more representative approach to contaminated land assessment.

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