IMS > Manual > Details

Integrated Management System for Prevention and Reduction of Pollution of Waterbodies at Contaminated Industrial Megasites

General procedure

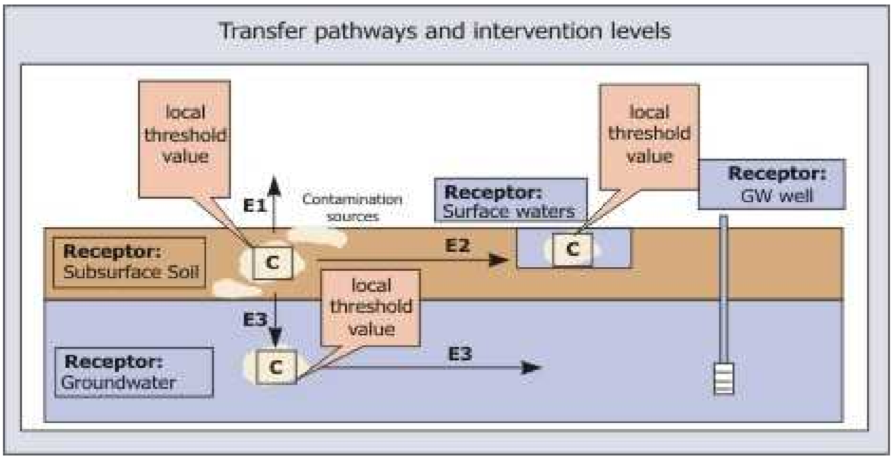
The risk assessment has to be carried out for the risk clusters within the preliminary Risk Management Zone (RMZ), and some area outside it, more specifically for:

a. the groundwater/surface water receptors inside and outside the RMZ,
b. receptors inside and outside the RMZ related to land use functions

The reason for this approach is that after the risk assessment some adjustments of the RMZ may be needed.

The risk assessment at megasites is based on estimates of site-specific risks, taking into account the site-specific conditions, the use of the site and its functions. There are several risks for human beings related to soil and groundwater contamination along different uptake pathways, for example through soil consumption, skin uptake, inhalation of volatiles (gas propagation), consumption of crops and drinking of contaminated groundwater. According to the Integrated Management System (IMS), each transfer pathway has to be taken into account. Depending on the relevant functions of diverse receptors, the following transfer pathways have to be considered in the F&T modelling and the risk assessment procedure.

- Pathway E1: Source – to receptor soil/land surface (different land-use functions, i.e. industrial, agricultural, residential and recreational use, and exposure pathways like ingestion, degassing etc.);
- Pathway E2: Source – to receptor surface water (different functions: aquatic ecosystem, and various utilisation functions, i.e. industrial, agricultural, recreational, and fishery use);
- Pathway E3: Source – to receptor groundwater (different functions: groundwater ecosystem, and various utilisation functions, i.e. industrial, agricultural, or drinking water use).



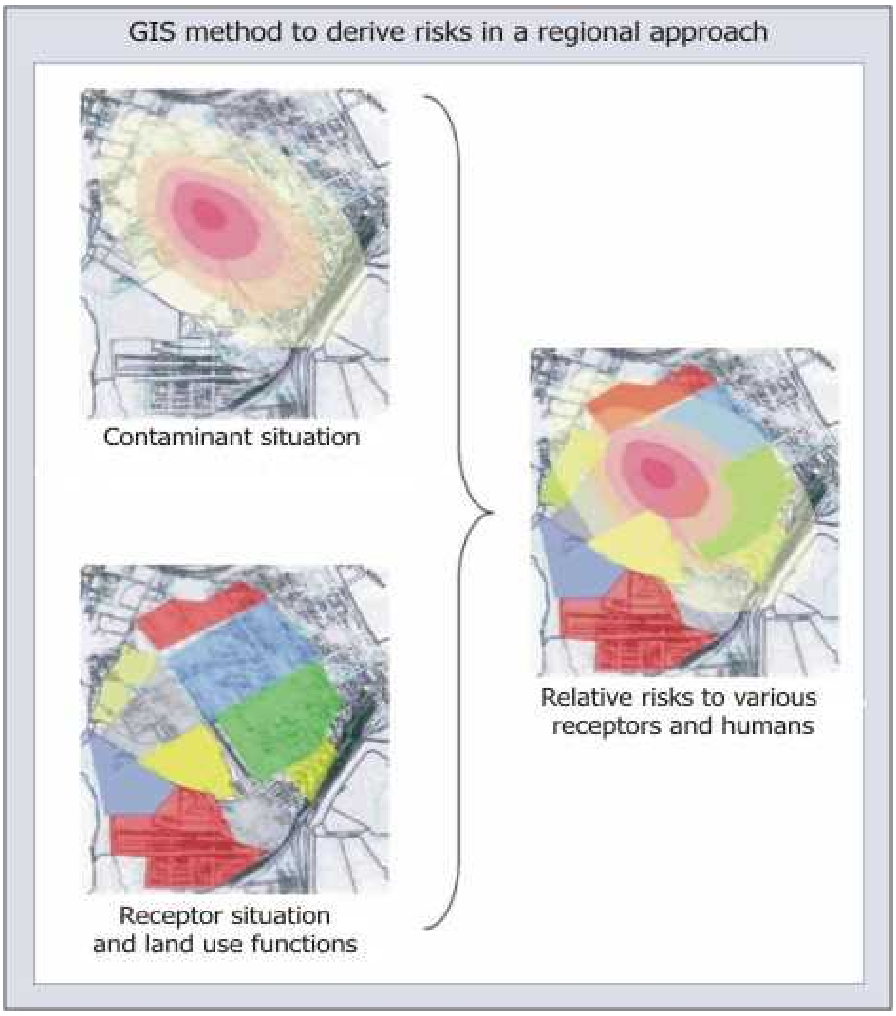
Ind = industry
Re(c) = recreational
Ec = ecological
Res = residential
SW = surface water
Dr = Drinking water
Agr = agricultural
A = Aquifer
I = intervention value
T = target value

Risks are generally indicated by:

- contaminant concentrations above respective standards,
- the probability of exposure

Based on these aspects, the contamination and the receptor situation can be compared. The recommended approach is a map-based combination of these sets of information for each cluster as follows (see figure):

The geographical distribution of concentration levels at different depths in the different media (soil, groundwater and soil air) is displayed in standardized (preferably GIS) maps, in relation to function oriented risk levels for each receptor. This relation is shown for different steps in time.



The display of this information gives a receptor-specific overview of the risk. The risk assessment needs to be carried out on a detailed level for each receptor. GIS methods are needed to store detail and overview risk assessment results.

The main steps of the risk assessment are as follows:

1. Comparison of the measured and calculated (current and prognosed) groundwater contamination with legal (ground)water quality standards (Water Framework Directive, Groundwater Directive) for each cluster in the megasite.
2. Comparison of the measured and calculated (current and prognosed) groundwater or surface water contamination inside the RMZ with the use-related legal quality standards (multifunctional). This is to be done on the cluster-basis, or for individual source-pathway-receptor sequences.
3. Comparison of the measured and calculated (prognosed) contamination situation with the receptors inside the RMZ other than groundwater and surface water, which represent site-specific functions (e.g. land use, current

surface water, which represent site-specific functions (e.g. land use, current and in future), and taking into account the different exposure pathways. This is done for each source-pathway-receptor sequence, based on the receptor-specific standards (threshold values, intervention values, etc.). The comparison at cluster-scale can be done e.g. by combining the resulting information in the form of GIS maps.

4. Comparison of the measured and calculated (prognosed) contamination with the receptors outside the RMZ other than groundwater represented by respective quality standards (e.g. surface waters), e.g. by combining the information in the form of GIS maps. This is done for each source-pathway-receptor sequence.

In terms of estimating risks one can follow a preliminary or comprehensive approach. These two approaches are described below.

Preliminary risk assessment

Prelimenary risk assessment is based on standardized protocols and current concentrations, and addresses current risks. Two procedures are available in the tool section.

Human health risks related to land-use functions: HIRET

A HIRET (GIS-based Health Index/Risk Evaluation Tool) has been developed for the integration of risk assessment and spatial planning using GIS capabilities. The method is meant to assist decision makers and site owners in the evaluation of potential human health risk with respect to land use. Human health risk defined as the characterization of the potential adverse effects on human life or health is generally accepted as the best method for site assessment and planning remediation strategies. It concerns polluted sites that endanger human health on one hand and derelict land that does not cause the immediate risk on the other hand. HIRET follows the methodology developed for human health risk assessment in aspect of spatial and temporal domain and is developed as an extension for ESRI ArcView 3.2 and allows performing dynamic human health risk assessment in long-term period, which is relevant for land use planning. More information can be found in tool section (see: *Tools -> HIRET*).

In order to quantify the risks for certain receptors of concern at the megasite, risk assessment models can be applied to single source-pathway-receptor sequences (e.g. the HIRET-tool for land-use and humans as the receptor).

Risk Assessment System: RAS

The RAS tool (see: *Tools -> RAS*) gives a systematic and tiered approach for addressing risks related to groundwater contamination, without applying the F&T modelling. At many megasites, this is a useful tool before going into a comprehensive risk assessment. To realize these steps based on a GIS-description, the so- called RAS-tool was developed and tested as an ArcView extension. This tool was applied at the Bitterfeld site (see: examples -> Bitterfeld).

Other risk assessment methods.

Many risk assessment methods are available for assessing risks per point concentration. Recently most of them were tested in terms of variability in risk predictions. For different receptors, results may vary in various orders of magnitude. The results indicate that extensive harmonization efforts and studies are still needed, to reduce the uncertainty and high variability of risk assessment results among the different models.

Comprehensive risk assessment

Using the F&T modelling allows for current and future risk determination in time and space. Modelling may also yield information on the uncertainty of the risk estimations. The models offer methodologies for estimating the exposure to a receptor and a future risk evaluation based on modelled prognosis. Furthermore, these methods can include an algorithm (e.g. the Monte Carlo simulation) for calculating the probability of receptors at risk. In some cases modelling results can be validated by monitored past and current concentrations along pathways, or at the receptors.

Modelling concentrations in soil, groundwater or air, following the source-pathway-receptor sequence, provides the basis for the risk assessment. By comparing the modelled concentrations with the national or European standards, present and / or future risks can be assessed. The probability of the exposure of receptors can be calculated by means of risk assessment models.

The risk assessment for megasites should be done in an approach taking into account the following factors:

- space: the contamination patterns in soil and groundwater as a function of X, Y and Z, in relation to land use (functions in the clusters);
- time: the contamination patterns as function of time for relevant priority contaminants, according to the results of the F&T modelling, at time 0, and after 5, 15, 30 and 50 (or sometimes 100) years.

Here no generic description is further given, but a short summary is presented of the outcomes of the comprehensive risk assessment for the megasites in the WELCOME project.

At Tarnowskie Góry, groundwater reactive transport modelling showed the expansion of boron plumes in the Triassic aquifers in a time range between the year 2000 and 2050. Within this time range the impacted aquifer volume is predicted to increase.

In Rotterdam Harbour, two estimates were made, namely (E2) - the impact of soil and shallow groundwater contamination on surface water quality for the year 2002, and (E3) - the impact of soil and shallow groundwater contamination on the deep regional Pleistocene aquifer in a time range from 1950 to 2100. Both assessments could not have been done without the regional F&T modelling. The predictions showed for surface water quality (E2) no significant deterioration originating from soil and groundwater contamination. An emission balance was made between the contributions of soil/groundwater contaminations, wastewater discharges within the Harbour region and the upstream contaminant inflow by the river. Soil and groundwater contamination have at this megasite no or a very limited effect on surface water quality. The deep groundwater (E3) receptor is an aquifer located at the depth of 20 to 30 meters below the entire Rotterdam Harbour area of 15 km to 40 km. For this it is predicted to be increasingly impacted in time. For some risk clusters an increase in impacted groundwater volume from 3 – 5 % to 15 – 20 % of the total groundwater volume is expected between 2050 and 2100. These findings were key points in the stakeholder group discussions on risks and risk reduction scenarios.

No comprehensive risk assessment based on the F&T modelling could be done for Bitterfeld region and the Antwerp megasite in the timeframe of the Welcome project, but it is planned for the future. At the Port of Antwerp, the hydrogeological situation is different compared to the Port of Rotterdam. In Antwerp, a thick clay layer is present (starting at a depth of 8 to 10 meters), channelling all contaminated groundwater towards the harbour surface water systems. The environmental risks in the Port of Antwerp are expected to be controlled by effects in the surface water and not by impacts on the deep groundwater, which is completely the opposite as for the Port of Rotterdam. For the Bitterfeld region, an extensive fate and transport modelling is under development by UFZ-Leipzig-Halle, and this is expected to lead to comprehensive risk assessments for the area in the near future.

Tarnowskie Góry, Rotterdam, Bitterfeld

Output:

The output of this step is a set of assessed risks, which are visualized in GIS maps for PoR, Btf and TG megasites (see: examples). The risk maps are generated for the relevant receptors, i.e. specifically for land use, groundwater and surface water.