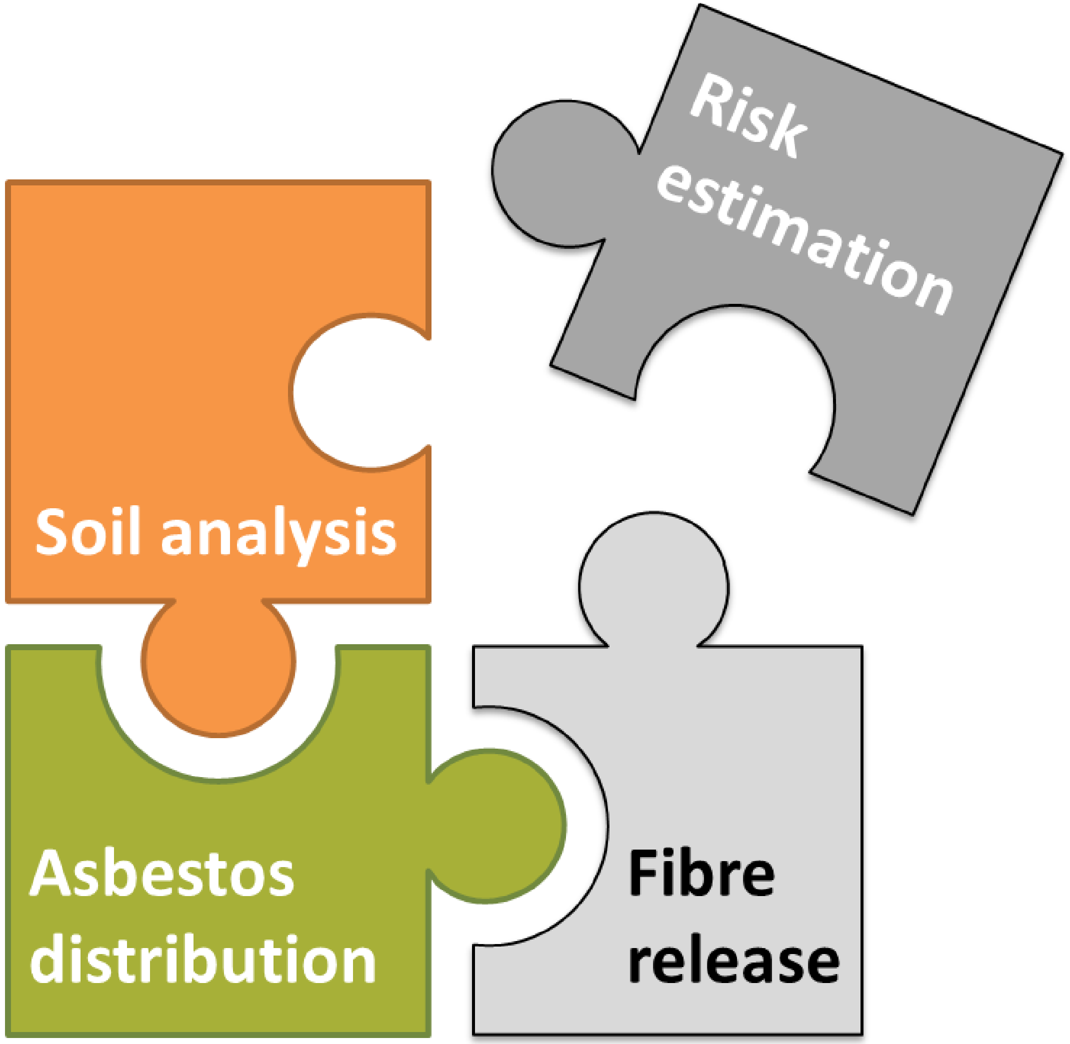
SoBRA Asbestos in Soil Human Health Risk Assessment (AiSHHRA) Toolbox



SoBRA asbestos sub-group

December 2021

Introduction

This interactive Microsoft Powerpoint toolbox has been designed by the SoBRA asbestos sub-group to assist risk assessors in undertaking asbestos in soil human health risk assessments.

It is a collation of the information sources and practices of the sub-group members, assembled in the form of a flowchart.

The toolbox provides users with summary information and links to relevant external reference sources, and advocates a process by which asbestos in soil risk assessment can be carried out.

It is hoped that it will aid in the consistency and robustness of asbestos in soil risk assessment.

Guide

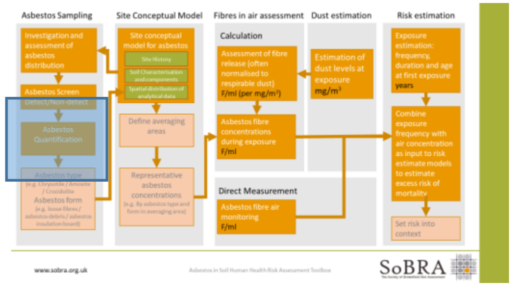
- The Human Health Risk Assessment (HHRA) Toolbox works using linked content that is set out and accessed by the main flowchart (slide 2)
- The content is split between process introduction slides, process options slides and information slides
- The information slides briefly summarise a description, further information, and SoBRA commentary

Note: In the context of the toolbox, 'soil' may be natural materials and/or made ground.

How to use

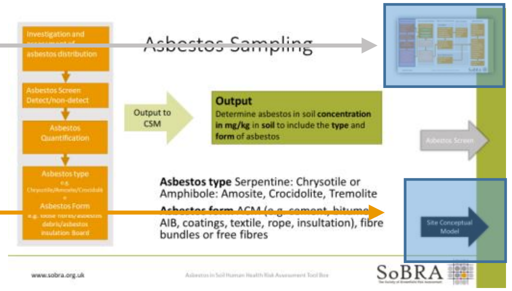
- Content is hyperlinked to facilitate movement between slides in accordance with the flowchart and the options chosen.
- On the main flowchart click to go to element of flowchart selected
- Click on thumbnail to return to slide shown
- Click arrow to forward to that section of the flowchart
- Click grey button to go to selected option

Flowchart element
Click to go to element

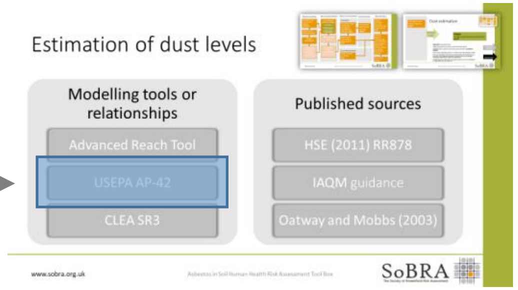


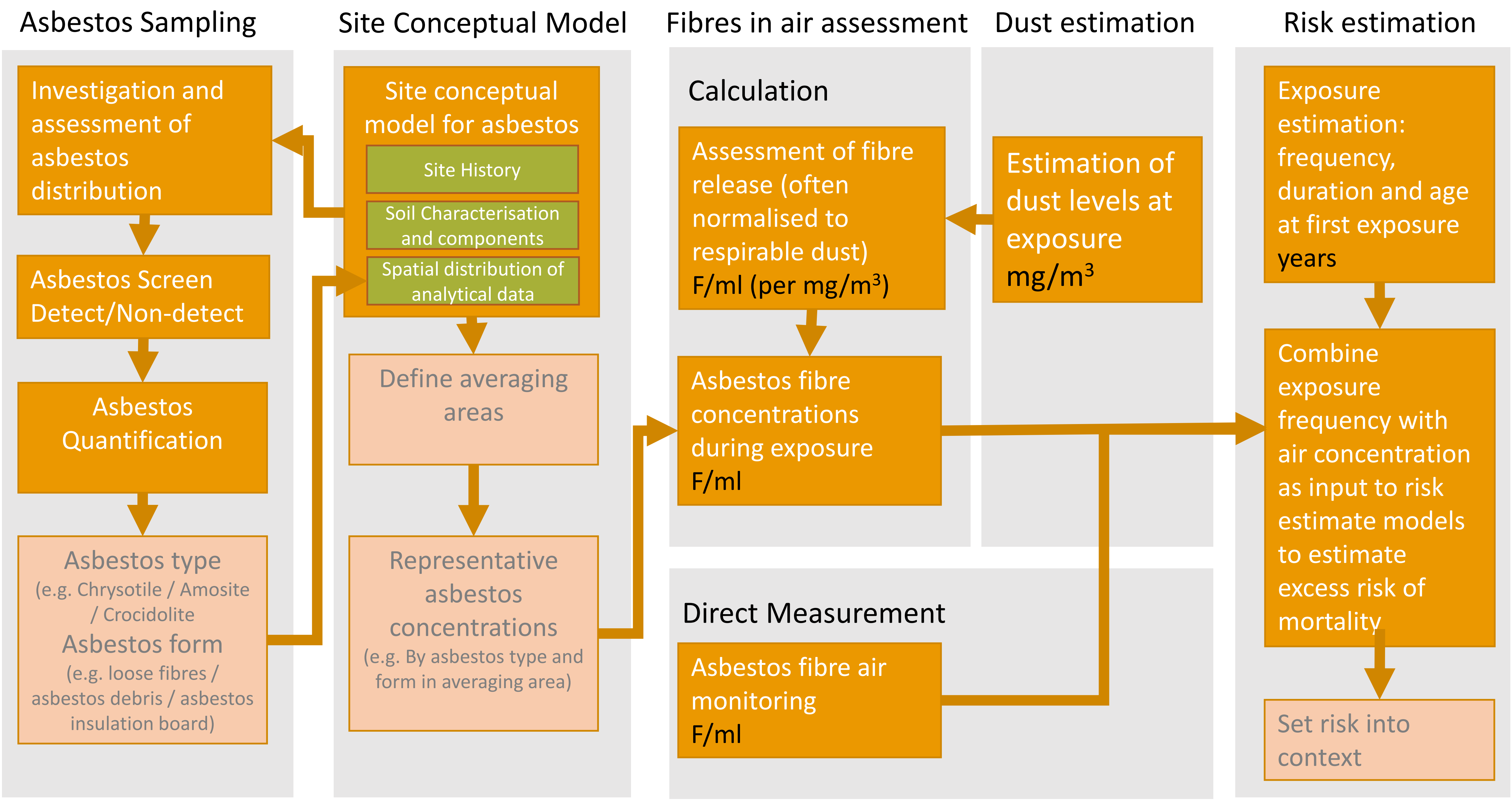
Slide thumbnail
Click to return to slide shown

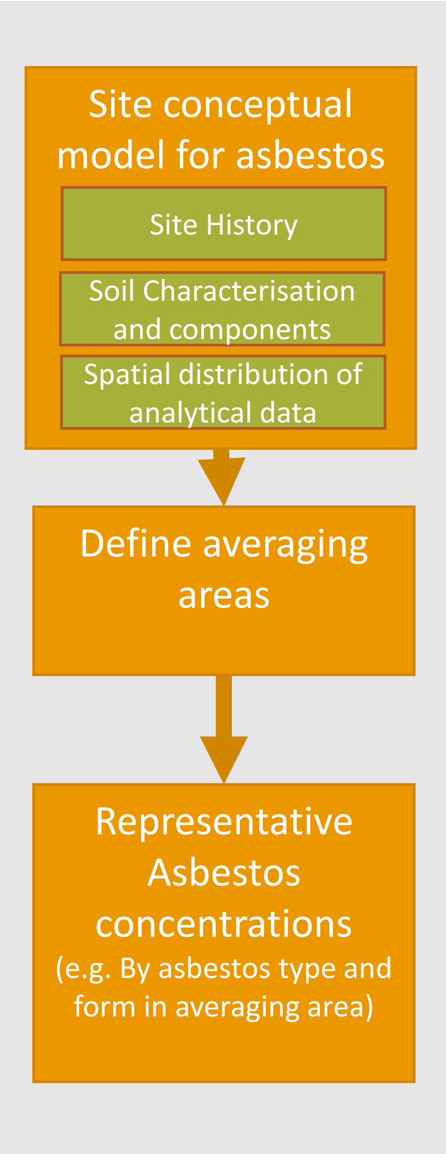
Destination arrow
Click to go to destination



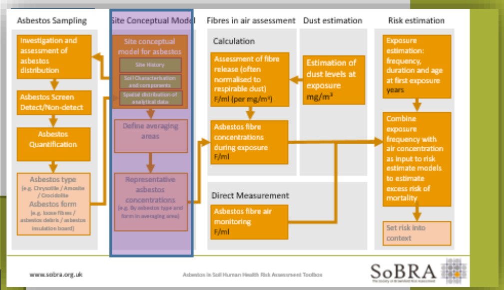
Option button
Click to go to option




Asbestos Sampling
Site Conceptual Model
Fibres in air assessment
Dust estimation
Risk estimation
Investigation and assessment of asbestos distribution
Asbestos Screen Detect/Non-detect
Asbestos Quantification
Asbestos type
(e.g. Chrysotile / Amosite / Crocidolite
Asbestos form
(e.g. loose fibres / asbestos debris / asbestos insulation board)
Site conceptual model for asbestos
Site History
Soil Characterisation and components
Spatial distribution of analytical data
Define averaging areas
Representative asbestos concentrations
(e.g. By asbestos type and form in averaging area)
Calculation
Assessment of fibre release (often normalised to respirable dust)
F/ml (per mg/m3)
Asbestos fibre concentrations during exposure
F/ml
Estimation of dust levels at exposure
mg/m3
Direct Measurement
Asbestos fibre air monitoring
F/ml
Exposure estimation: frequency, duration and age at first exposure years
Combine exposure frequency with air concentration as input to risk estimate models to estimate excess risk of mortality
Set risk into context



Site Conceptual Model



The Site Conceptual Model is the fundamental understanding of the behaviour and distribution of the various types and forms of asbestos present on a site and how the various people accessing the site and surrounding area may be exposed to asbestos. It should be continuously developed as new data arises.

Some of the key factors that may be considered in the site conceptual model are :

Asbestos behaviour in soil – asbestos in soil is generally not mobile in soil and thus will tend to stay within the soil where placed, unless the soil is disturbed.

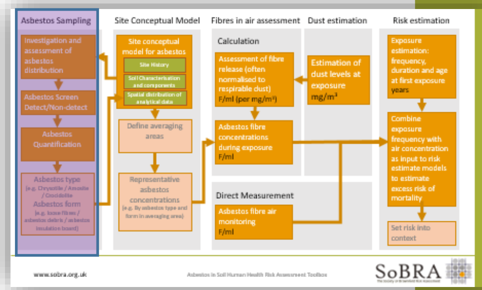
Pathways and receptors - asbestos causes harm to people via inhalation of fibres and thus exposure will only occur where people have inhaled soil dust either via soil tracked back into buildings or while they are outdoors at the site. Much of the rest of the assessment in this toolbox focusses on quantifying the release of fibres when soil is disturbed. It may be possible screen out risks to some of all of the people potentially affected at an early stage, for instance where asbestos is or will be present at depth or below hardstanding and will not be disturbed.

Source information including

- Site History – Where asbestos may have arisen, how it has got into the soil, and whether there have been activities that may have moved soil containing asbestos around either by excavation or tracking across the site if present at the surface. Historical aerial photos, in addition to historical maps and site records such as asbestos registers, can be invaluable to support this.
- Information on ground conditions- The components in soil such as different types of building rubble can be a very useful indicators of the potential for asbestos. The soil type that asbestos is mixed in is likely to affect the distribution within the soil. Information on ground conditions should be used to inform and update the sampling and analysis strategy, and used in interpreting site data to establish the vertical and lateral distribution of asbestos as well as identifying data gaps.
- Analytical data on asbestos – This should take into account the types and forms of asbestos components as well as concentration within the samples. Where possible consideration should be given to linking these back to the soil types and potential sources from the site history to better understand the distribution.

Asbestos sampling

Asbestos Sampling



Investigation and assessment of asbestos distribution

↓

Asbestos Screen Detect/Non-detect

↓

Asbestos Quantification

↓

Asbestos type
e.g. Chrysotile/Amosite/Crocidolite
Asbestos form
e.g. loose fibres/asbestos debris/asbestos insulation Board

Output to CSM →

Output
Determine asbestos in soil **concentration in mg/kg** in **soil** to include the **type** and **form** of asbestos

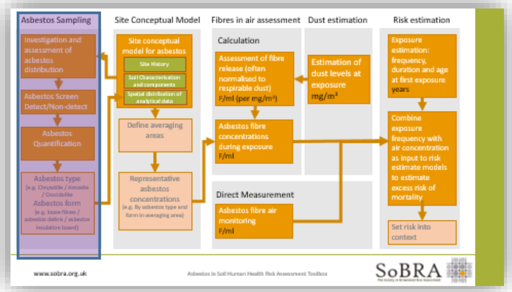
Sampling methods →

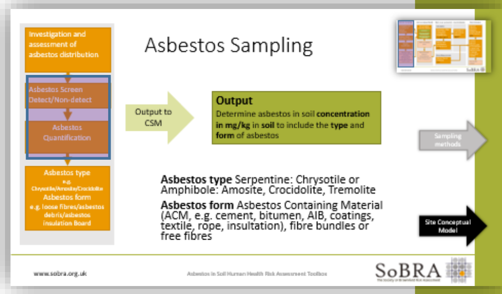
Asbestos type Serpentine: Chrysotile or Amphibole: Amosite, Crocidolite, Tremolite

Asbestos form Asbestos Containing Material (ACM, e.g. cement, bitumen, AIB, coatings, textile, rope, insultation), fibre bundles or free fibres

Site Conceptual Model →

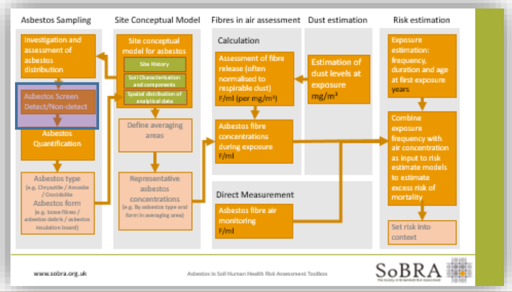
Asbestos sampling

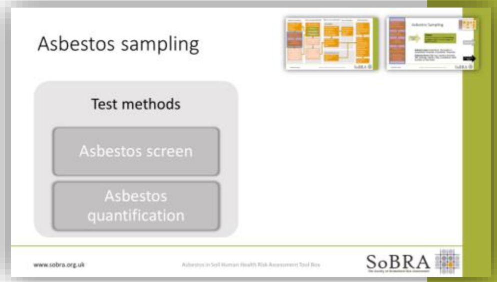




Test methods

- Asbestos screen
- Asbestos quantification





Asbestos Screen

Description: The “asbestos screen” is Stage 1 of the (now withdrawn) Standing Committee of Analysts Blue Book Method (SCA BBM) and is detailed in Appendix 2 in HSG248, and is the determination and identification of presence or absence of asbestos using stereomicroscopy, plus higher magnification polarised light microscopy (PLM) analysis for fine fibres.

The Stage 1 assessment undertaken by laboratories provides an initial assessment of the presence of asbestos in the soil sample visually inspected. Samples may be subject to some form of preparation prior to Stage 1 (depending on the laboratory) and the sample size inspected at Stage 1 varies between laboratories ranging from the entire 1kg to a subsample of 100g or less.

Reporting is as No Asbestos Detected ‘NAD’ or if present, the type and form of asbestos will be reported. The results are therefore qualitative not quantitative.

Further information: Health and Safety Executive. (2021) Asbestos: The Analysts’ Guide. HSG248 2nd edition May 2021. https://www.hse.gov.uk/pubns/books/hsg248.htm

SCA Blue Book (now withdrawn) https://www.claire.co.uk/home/news/59-sca-blue-book-method-the-determination-of-asbestos-in-soil-and-associated-materials-consultation-draft-now-available

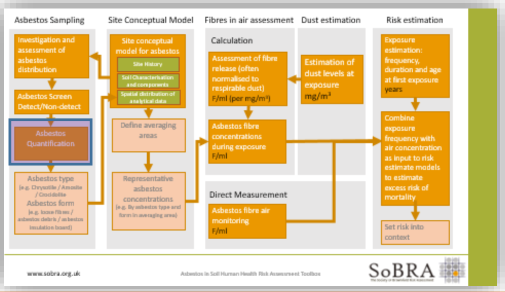
SoBRA discussion paper on laboratory methods https://sobra.org.uk/?pmpro_getfile=1&file=2021/02/SoBRA-paper-on-laboratory-test-methods_Dec2020_final-for-publication&ext=pdf

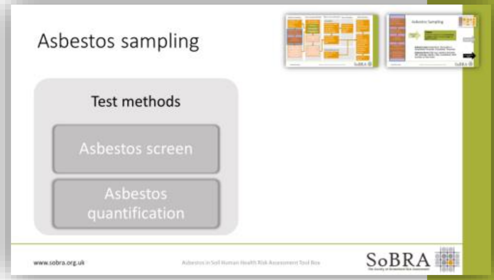
SoBRA comment: The SCA BBM was withdrawn in December 2020 and HSG248 2nd edition published in May 2021. The 2nd edition of HSG248 changes the analytical approach to laboratory testing such that it deviates from the Blue Book method and is not focused on providing relevant information for supporting human health risk assessment.

SoBRA published a discussion paper on the results of a survey of UK laboratories in February 2021 and this identified that sample preparation (e.g. sieving, drying, and crushing of samples) could have a substantial impact on the ability to identify asbestos compared to visual inspection of an “as received” sample. It also identified that the condition of the asbestos identified is not typically reported, and that laboratories do not routinely report at what sub-stage within Stage 1 asbestos was detected (i.e. during visual inspection using stereomicroscopy or during higher magnification PLM microscopy), and therefore when the sample inspection stopped. The discussion paper made a series of recommendations for the reporting of laboratory test results, including for steps 1-3 of the asbestos screening stage.

Asbestos in soil Output

Asbestos Quantification





Description: Stage 2 of the SCA BBM: The removal of asbestos containing material (ACM) and fibre bundles with identification and gravimetric analysis to determine percentage by weight.

Stage 3 of the SCA BBM: The dispersion and collection of free fibres followed by fibre identification, counting and measurement of fibres to determine percentage by weight (undertaken when the asbestos is not suitable for gravimetric quantification – if no ACM or fibre bundles are detected but free fibres are identified).

The sample size inspected at Stage 2 varies between laboratories ranging from the entire 1kg to a subsample of 100g or less; the majority of laboratories use the same sub-sample from Stage 2 for Stage 3.

Further information: Health and Safety Executive. (2021) Asbestos: The Analysts' Guide. HSG248 2nd edition May 2021. https://www.hse.gov.uk/pubns/books/hsg248.htm

SCA Blue Book (now withdrawn) https://www.claire.co.uk/home/news/59-sca-blue-book-method-the-determination-of-asbestos-in-soil-and-associated-materials-consultation-draft-now-available

SoBRA discussion paper on laboratory methods https://sobra.org.uk/?pmpro_getfile=1&file=2021/02/SoBRA-paper-on-laboratory-test-methods_Dec2020_final-for-publication&ext=pdf

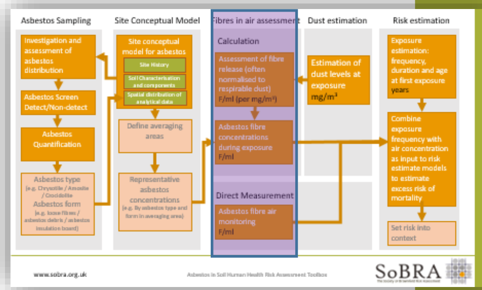
SoBRA comment: The current limits of quantification reported are typically 0.001 % w/w and the asbestos content is typically reported on a dry weight basis. It is rare that the quantified amounts are attributed to individual asbestos types or forms – a significant limitation in the reported results.

Be aware that where asbestos content is reported for an asbestos containing material, the "book value" for the percent of asbestos present in the material is often not consistent between laboratories. Also be aware that laboratories use different particle sizes for the Stage 3 analysis.

Recommendations for the reporting of Stage 2 and Stage 3 results are provided in the SoBRA discussion paper.

Asbestos in soil Output

Fibres in air assessment – Calculation



Calculation

Assessment of fibre release (often normalised to respirable dust)
F/ml (per mg/m³)

Asbestos fibre concentrations during exposure
F/ml

Direct Measurement

Asbestos fibre air monitoring
F/ml

Input dust concentrations from Dust Estimation

Asbestos in Soil Dust Estimation from site data and CSM

Use to calculate cumulative exposures

Output

Fibre release x Dust concentration

OR air monitoring results

Weighted average asbestos concentration for each asbestos type and each zone (if defined)

f/ml

Asbestos fibre concentrations for the risk assessment should be calculated from **asbestos fibre release data** and **estimated dust concentrations**. They may also be directly measured via **asbestos fibre in air monitoring**, but only if the activity under assessment is already in progress.

Fibre concentrations should be estimated within the breathing zone for each, or for the highest sensitivity, receptor(s) and as an average during the exposure(s) subject to assessment.

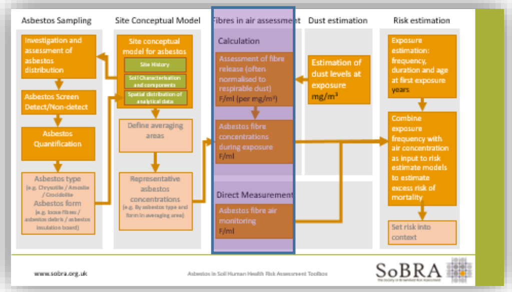
Assessment of fibre release

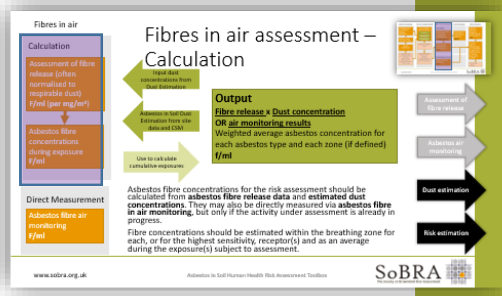
Asbestos air monitoring

Dust estimation

Risk estimation

Assessment of fibre release





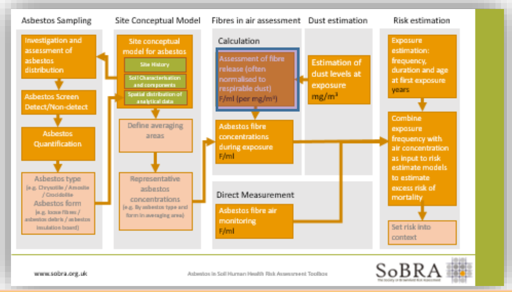
Test methods

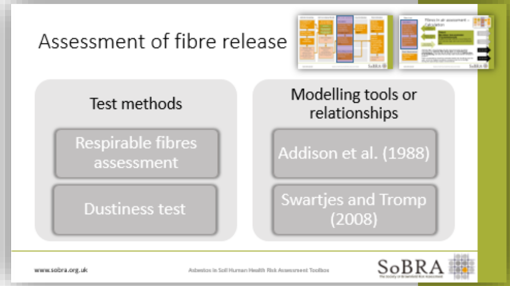
- Respirable fibres assessment
- Dustiness test

Modelling tools or relationships

- Addison et al. (1988)
- Swartjes and Tromp (2008)

Respirable fibres assessment





Description: Commonly used laboratory analytical methods (including the Blue Book) do not report respirable fibre concentrations as standard. Gravimetric analysis in particular does not distinguish between respirable and non-respirable fibres.

Respirable fibre assessment is a defined step in the Dutch (Ministry of Housing, Spatial Planning and the Environment (VROM)) guidance (Tier 3) and a small number of UK laboratories offer respirable fibre quantification as an optional additional step in asbestos quantification analysis. Typically this is reported as respirable fibres per gram of soil, and can be reported for a specific size fraction of soil if required.

Further information: Dutch Soil Remediation Circular 2013 Annex 3 [Note: this is now difficult to find online in English – this link provides information on the Circular but not access to the Circular itself] https://rwsenvironment.eu/subjects/soil/legislation-and/soil-remediation/

Commercial laboratory test method information

SoBRA comment: This can be an advantageous additional step if it is believed that a large percentage of the detected asbestos fibres are not respirable.

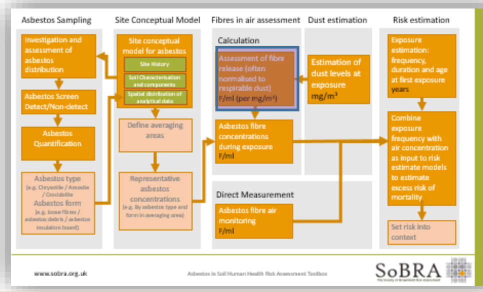
It can allow calculations to be done to estimate the potential respirable fibre concentrations in airborne dust if the test is done on the dust (e.g. PM_{10}) size fraction of the soil, thus either avoiding or providing an independent line of evidence to support the results of soil to air release estimates that are based on %wt/wt soil results.

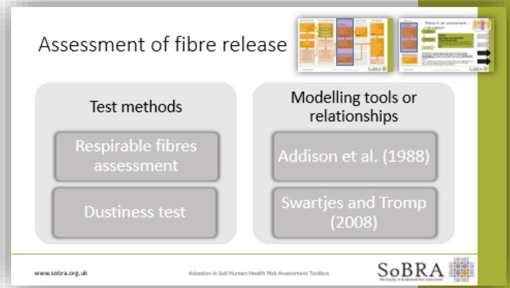
Like all risk assessment approaches based on soil sample data the assessment is only as good as the data on which it is based. This step is best done when robust data sets are available rather than at preliminary investigation stages.

The assessment requires a good understanding of whether the generation of additional respirable fibres is possible in the future as a result of future ground disturbance. Do the respirable fibre concentrations reported now represent what land users might be exposed to in the future. It is therefore of potentially greatest benefit when only loose free fibres have been detected.

Respirable fibres Output

Dustiness test





Description: In soil, asbestos can be bound in bundles/bitumen/concrete etc. and can therefore have limited capability to become airborne.

This method attempts to quantify the concentration of asbestos in dust generated from soil and allows a risk assessor to demonstrate the potential risk of asbestos in soil becoming airborne.

The testing is typically carried out on standard soil samples collected by an intrusive investigation, reflecting ground conditions at the time of sampling, but can also be conducted using laboratory prepared samples. It is possible to vary the moisture content of the tested sample to mimic different soil conditions and to determine a concentration above which dust release is more or less likely.

Results are typically reported for the airborne fibre concentration and the airborne dust concentration. It may also be possible for the laboratory to report for different asbestos types if it is known in advance that the test samples contains a mix of asbestos.

Further information: BS EN 15051-2:2013+A1:2016. Workplace exposure. Measurement of the dustiness of bulk materials. Rotating drum method.

Fact sheets are available from commercial laboratories

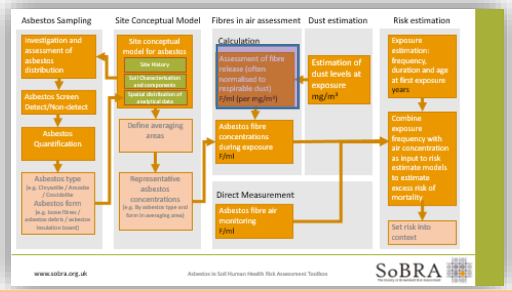
SoBRA comment: This can be a useful tool to compare with model predictions of dust release. The method of dust estimation is based on a standard laboratory procedure to estimate dust and is available with UKAS accreditation.

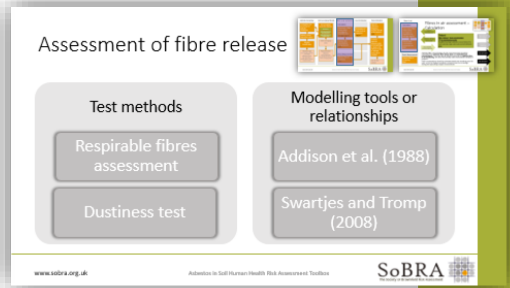
The results are prone to variability and tests should be run on multiple samples to produce a more reliable result. High amounts of dust from certain soils types can adversely affect the testing by masking filters and preventing fibre detection/increasing limits of quantification. Similarly the clumping of soil in the drum may adversely affect results by restricting dust and fibre release (an issue particularly for damp fine particle soils).

Be aware of the definition used for the dust concentrations reported and whether they are consistent with the definitions or measurements used in other lines of evidence (e.g. total inhalable dust, total dust, PM_{10}, respirable dust).

Fibre release Output

Modelling relationship Addison et al. (1988)





Description: Laboratory experiments measured asbestos fibre concentrations in air (f/ml) arising from the generation of dust clouds of 5mg/m^3 respirable dust concentration within a 1.3m^2 test chamber, from 32 mixtures of different soil types (clay, sand, and intermediate soil), with three asbestos types (chrysotile, amosite and crocidolite) and at varying concentrations (1%, 0.1%, 0.01% and 0.001% by weight). Variation with soil moisture content (0% - 50%) was also investigated. The study normalised airborne fibre concentrations to the respirable dust concentrations.

Relationships were presented for asbestos fibres in air and asbestos concentration in soil, and these relationships were presented separately for asbestos type, soil type, and soil moisture.

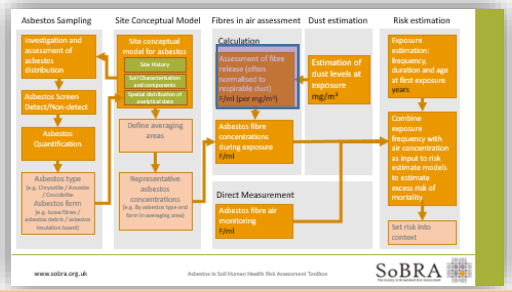
Further information: Addison J, Davies LST, Robertson A, Willey RJ,. 1988. The release of dispersed asbestos fibres from soils. IOM. Historical Research Report. Report TM/88/14. https://library.iom-world.org/media/69461/IOM_TM8814.pdf

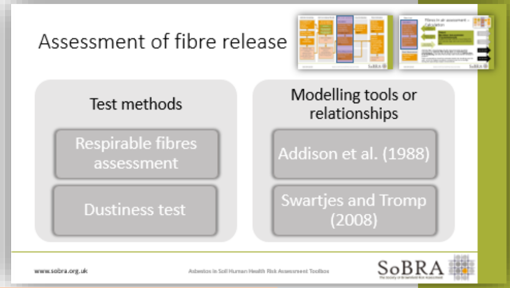
SoBRA comment: The study allows for estimation of potential fibre release from soils based on soil asbestos concentration, soil type, and moisture content. However there are a number of limitations to the study.

It was limited to generation of dusts at a 5mg/m^3 nuisance limit and comparison of asbestos air concentrations to indoor clearance limits (0.01 f/ml) at the time. Mineral dust in samples posed issues with counting fibre concentrations to limits of 0.01 f/ml. It is not clear how the dust generation and sample preparation methods relate to real-world conditions. Only a very small number of samples were tested for each variable. To identify a relationship between soil concentration and air concentration required log-log scales which significantly mask variability in individual results.

Fibre release Output

Modelling relationship Swartjes and Tromp (2008)





Description: The report details the methodology for developing intervention values and a tiered assessment process for asbestos in soil for use in the Netherlands. The report describes the results of laboratory experiments and activity-based sampling from sites with known asbestos in soil content. The report presents the relationship between asbestos concentration in soil and measured airborne asbestos concentrations.

The report also details the use of a dust emission model (PLUIM-PLUS) to provide an indication of the average fibre concentration with distance from the emission source. The emission modelling estimated that airborne fibres from soil were <1000 fibres/m^3 at distances over 100m from the emission source.

Further information: Swartjes, F. A, & Tromp, P. C. 2008. A tiered approach for the assessment of the human health risks of asbestos in soils. Soil & Sediment Contamination, 17:137-149. https://www.tandfonline.com/doi/abs/10.1080/15320380701870484?journalCode=bssc20

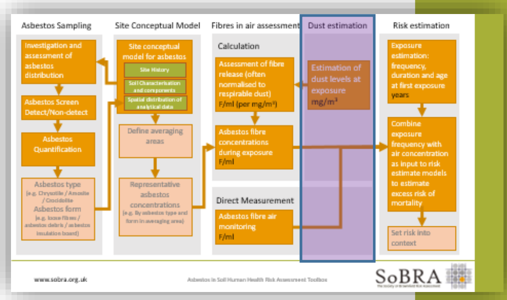
SoBRA comment: The report provides a line of evidence based on real-world data for asbestos fibre release during site activities as well as based on laboratory experiments similar to Addison et al., 1988. A key limitation is the lack of detail in the activities monitored and the environmental conditions under which the activities were monitored. Additionally, the relationship provided is based on the aggregation of all the activities monitored – there is no separation of activity-type. It does not distinguish between asbestos type, soil type, or soil moisture content, or explain how the representative soil and air concentrations used in the data evaluation were chosen/defined.

The high number of studies undertaken do however allow for estimation of asbestos fibres in air arising from a different soil concentrations and provide an "envelope" of potential fibre in air concentrations from which to compare to other more theoretical estimations.

Fibre release Output

Estimation of dust levels at exposure **mg/m^3**

Dust estimation



Output dust levels for use Fibres in air assessment – calculations

Output

Average or worst-case dust concentration

mg/m^3

Respirable dust portion only

Highly dependent on moisture content and wind levels

Multiple values could be used in the assessment for a **sensitivity analysis**

Sense check calculated values or model results with published values

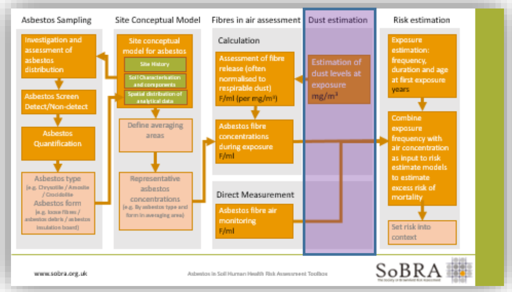
Dust concentrations should be estimated within the breathing zone for each receptor, or for the highest sensitivity receptor(s), and as an average during the exposure(s) subject to assessment.

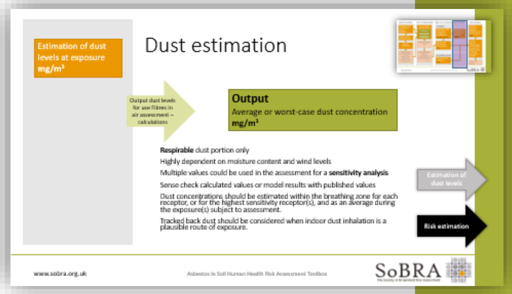
Tracked back dust should be considered when indoor dust inhalation is a plausible route of exposure.

Estimation of dust levels

Risk estimation

Estimation of dust levels





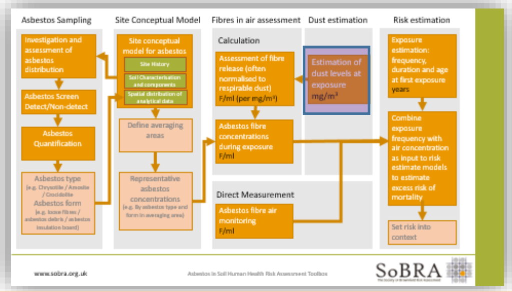
Modelling tools or relationships

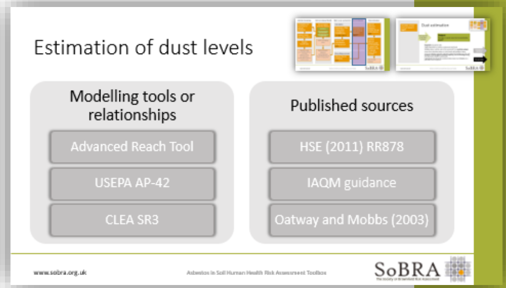
- Advanced Reach Tool
- USEPA AP-42
- CLEA SR3

Published sources

- HSE (2011) RR878
- IAQM guidance
- Oatway and Mobbs (2003)

Advanced Reach Tool





Description: The Advanced Reach Tool (ART) is available as part of the European Chemical Agency (ECHA) collection of tools and guidance for chemical assessment under the EU Registration, Evaluation, Authorisation and Restriction (REACH) Regulation. The tool allows users to set up generic occupational work activity scenarios for different types of materials and environmental conditions and predict the potential airborne dust concentrations that might be associated with such scenarios.

It was used by the authors of CIRIA C733 to estimate potential dust concentrations during gardening – in this case by using the ART option for the manual shovelling of coarse powders.

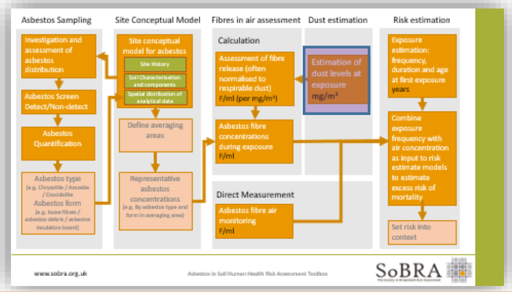
Further information:

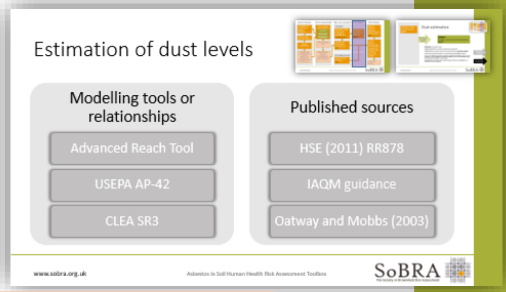
Advanced Reach Tool. https://advancedreachtool.com/

Nathanail, C P, Jones, A, Ogden, R, Robertson, A (2014). Asbestos in soil and made ground: a guide to understanding and managing risks (CIRIA C733).

SoBRA comment: ART can provide a useful line of evidence for determining potential airborne dust concentrations that receptors might be exposed to and is supported by detailed validation. The tool is designed for, and has been validated against, specific occupational scenarios and often these scenarios do not directly match the soil exposure scenarios being evaluated in the context of asbestos in soil.

Dust Estimation Output





USEPA AP-42

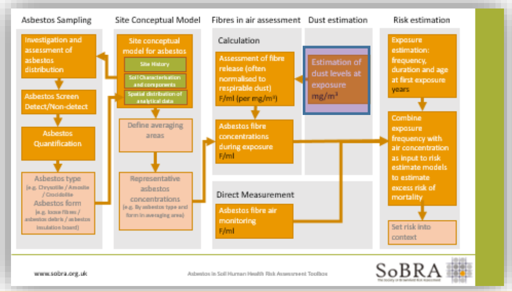
Description: AP-42: Compilation of Air Emissions Factors, is the primary source used by the US EPA for information concerning emissions factors, developed and compiled from test data and engineering estimates. Chapter 13.2 of AP-42 covers fugitive dust sources, estimating dust emissions from the disturbance of granular material, and consequently is the most relevant section of AP-42 for considering emissions from brownfield activities. The two main physical actions involved in this process are the pulverisation and abrasion of surface materials by the application of mechanical force, and the entrainment of dust particles by the action of turbulent air currents. The most relevant sub-sections area likely to be those on emissions from heavy construction operations, aggregate handling and storage piles, unpaved roads, and industrial wind erosion.

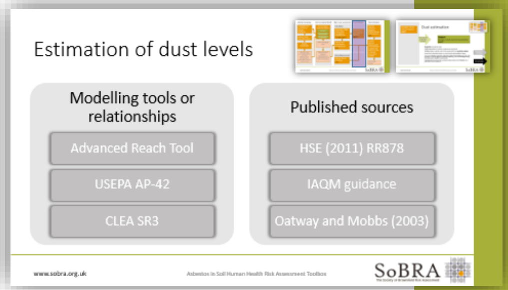
Further information:

AP42 https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors

SoBRA comment: The AP-42 guidance is detailed, and is "tried and tested" having been originally published in the 1972 and last updated for Chapter 13: Miscellaneous Sources in 1995 and 2006. The algorithms for fugitive dust emissions allow for site-specific characteristics to be taken into account (such as material moisture content and particle size distribution). The guidance does not cover individual manual activities (rather focusing on larger site-wide mechanical activities), and care needs to be taken on parameter units (US imperial).

Dust Estimation Output





CLEA SR3

Description: The report describes the technical approach adopted by the Environment Agency, in England, to develop Soil Guideline Values. Soil-derived dust concentrations are estimated in ambient air using a generic approach for wind erosion developed by Cowherd *et al.,* (1985). A particle emission flux (PEF) for PM_{10} (dust particles of <10µm diameter) is estimated based on the fraction of outdoor surface cover, the mean annual wind speed and threshold value of wind speed at a height of 10m, and an empirical constant.

A conservative correction factor is used to account for surface roughness as a result of non-erodible elements in soil (i.e. grass or stones) – the PEF is highly sensitive to this value. Indoor dust is assumed as 50µg/m^3 for residential and 100µg/m^3 for commercial premises based on literature data with a tracked-back indoor dust fraction of 0.5.

Further information:

Environment Agency (2009). Updated technical background to the CLEA model. Science Report: SC050021/SR3. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291014/scho0508bnqw-e-e.pdf

Cowherd, C., Muleski, G.E., Englehart, P.J., Gillette, D.A., 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination sites. Report EPA/600/8-85/002. United States Environmental Protection Agency.

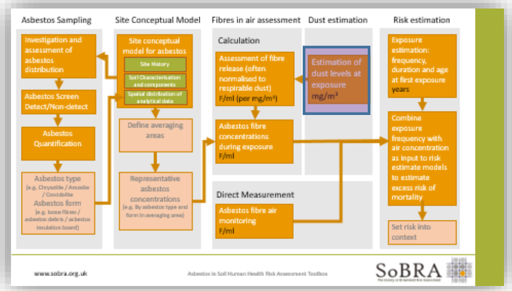
SoBRA comment: This method is only applicable when considering dust levels caused by wind erosion of the soil surface. It is not applicable for soil disturbance caused by human activity.

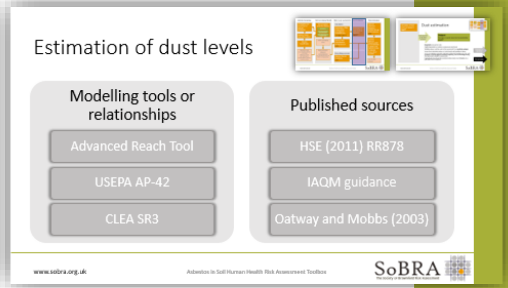
The PEF as modelled in CLEA is specific to PM_{10} dust concentrations. Various factors are included that are noted to be conservative and can be adjusted using site-specific data.

The tracked-backed fraction of soil that contributes to indoor dust is a highly uncertain parameter value.

Dust Estimation Output

HSE (2011) RR878





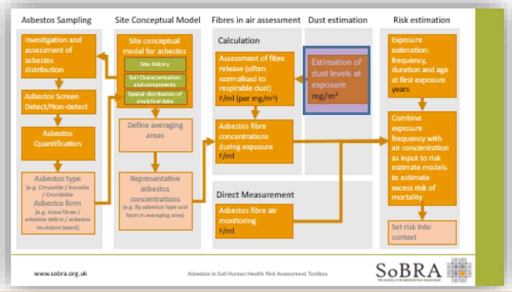
Description: HSE Research Report 878 details research carried out by the HSE into levels of respirable dust and respirable crystalline silica at construction sites. The pilot study looked at the potential for inadvertent exposure of the public to respirable crystalline silica from construction activities by monitoring the respirable dust from, demolition, block cutting, road building, general construction activities and city centre air. In total there were 13 visits to seven sites, with 48 air samples from construction activities and 11 city centre air samples.

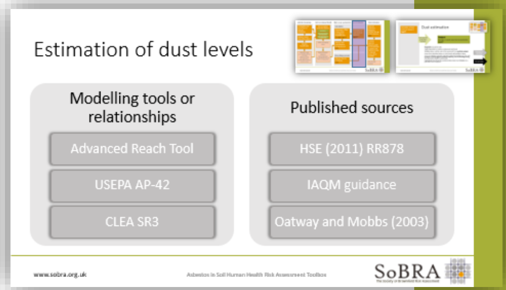
Further information:

HSE (2011). Levels of respirable dust and respirable crystalline silica at construction sites, Research Report RR878, Health and Safety Laboratory, Buxton, 2011 https://www.hse.gov.uk/research/rrpdf/rr878.pdf

SoBRA comment: Whilst this is only a pilot study it provides published data on respirable dust levels associated with various construction activities, and comparison to background city centre concentrations. These measured concentrations may only be indicative of the sort of airborne dust levels generated by such activities but are a line of evidence that can be compared to modelled or other estimates of dust levels adopted in risk assessments.

Dust Estimation Output





IAQM guidance

Description: The UK Institute of Air Quality Management (IAQM) has published a series of guidance documents associated with the monitoring and assessment of dust from demolition and construction activities.

The 2014 Guidance on the assessment of dust from demolition and construction presents a qualitative assessment methodology for categorising the risk to receptors from dust emissions based on the dust generation potential of different activities and the sensitivity (e.g. proximity) of receptors.

The 2018 Guidance on Air Quality Monitoring in the Vicinity of Demolition and Construction present good practice for site dust monitoring and site action levels.

Further information:

Holman et al (2014). IAQM Guidance on the assessment of dust from demolition and construction, Institute of Air Quality Management, London. www.iaqm.co.uk/text/guidance/construction-dust-2014.pdf

Moorcroft, S (2018). IAQM Guidance on Air Quality Monitoring in the Vicinity of Demolition and Construction Sites

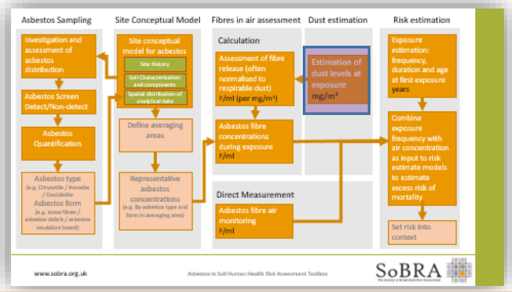
https://iaqm.co.uk/text/guidance/guidance_monitoring_dust_2018.pdf

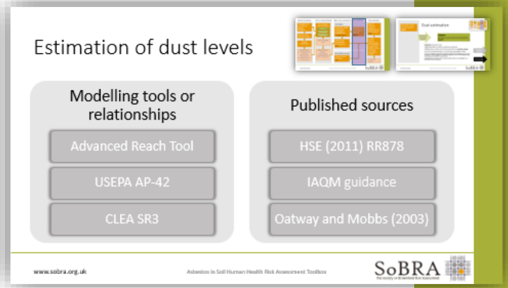
SoBRA comment: The 2014 guidance identifies important factors to consider in assessing the dust generation potential of demolition and construction activities and a methodology for combining these factors with receptor sensitivity to provide a qualitative ranking for dust risk.

However, the guidance is qualitative and does not provide quantitative estimates of dust emissions from different activities. The 2018 guidance provides typical guidance on monitoring techniques and on site action levels, the latter being dust levels that could be used as assumed site dust concentrations if good dust management practices are employed onsite.

Dust Estimation Output

Oatway and Mobbs (2003)





Description: This UK report on a methodology for assessing exposure to the public from future use of radioactive contaminated land includes a sub-section on inadvertent inhalation of suspended soil particles. The report states that the values in the methodology are considered applicable for the UK. Table 4 in the document provides dust loading (g.m^{-3}) for six generic land use scenarios – agriculture, recreation, construction, school, industrial and housing. Table 4 differentiates the dust loadings into “Unenhanced, ambient dust loading” and “Enhanced outside dust loading". The detailed assumptions adopted for each scenario are provided in the accompanying appendix for each scenario.

Further information:

Oatway & Mobbs (2003). Methodology for estimating the doses to members of the public from the future use of land previously contaminated with radioactivity. NRPB-W36, National Radiological Protection Board, Chilton. https://webarchive.nationalarchives.gov.uk/ukgwa/20140721222816/http://www.hpa.org.uk/Publications/Radiation/NPRBArchive/NRPBWSeriesReports/2003nrpbw036/

SoBRA comment: The dust loading factors are all based on referenced documents specific to the scenarios adopted. The enhanced dust loading factor, as discussed in the report, is typically the ambient dust loading x 10 (or greater). The report provides a useful condensation of published research (at the time of publication) on ambient dust levels relevant to different land use scenarios, and provides a peer reviewed approach to estimating enhanced dust levels due to human activity.

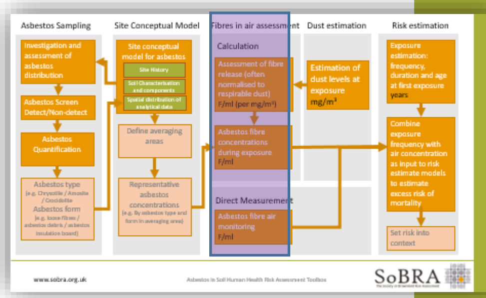
Dust Estimation Output

Fibres in air

Direct Measurement

Asbestos fibre air monitoring
F/ml

Fibres in air assessment – Direct Measurement



Output
Air monitoring results
Weighted average asbestos concentration for each asbestos type and each zone (if defined)
f/ml

Asbestos fibres may also be directly measured via **asbestos fibre in air monitoring**, but only if the activity under assessment is already in progress or by using activity based sampling methods.

Fibre concentrations should be estimated within the breathing zone for each receptor, or the highest sensitivity receptor(s), and as an average during the exposure(s) subject to assessment.

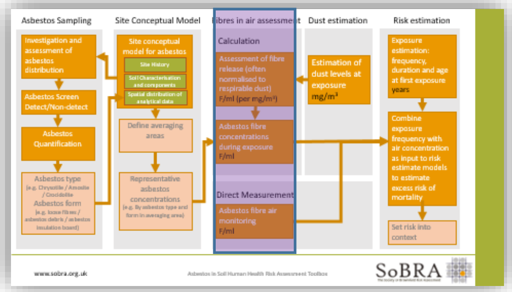
Assessment of fibre release

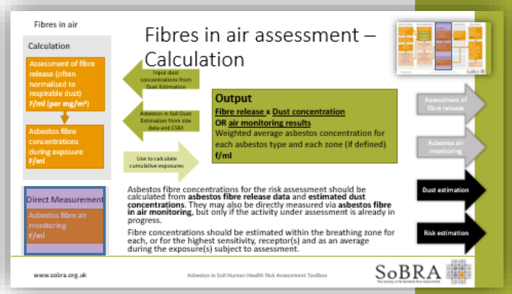
Asbestos air monitoring

Dust estimation

Risk estimation

Direct measurement





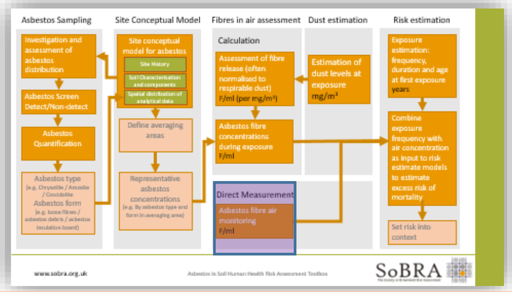
Air monitoring methods

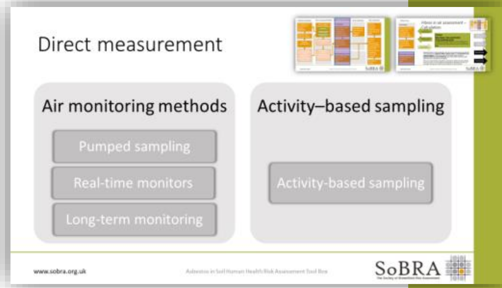
- Pumped sampling
- Real-time monitors
- Long-term monitoring

Activity–based sampling

- Activity-based sampling

Pumped Air Sampling





Description: Direct air measurement is achieved by collecting fibres on a filter by drawing a known volume of air through a pump. The filter is then examined by one of three different types of microscopy to count the airborne fibres over a specific area of the filter (graticules).

The principal guidance for the measurement of asbestos fibres in air is the HSE publication HSG248. This requires fibres to be counted if they are >5µm long and <3µm wide and length to width ratio of >3:1 using phase contrast microscopy (PCM). The limit of detection of the analysis can be reduced by sampling for a longer period of time, using duplicate or triplicate pumps, and/or by counting more graticule areas. Alternative scanning electron microscopy (SEM) or transmission electron microscopy (TEM) methods can also be used.

Further information: Health and Safety Executive, (2021). Asbestos: The Analysts' Guide. HSG248 2nd edition May 2021.
https://www.hse.gov.uk/pubns/books/hsg248.htm

SoBRA (2015). Airborne Asbestos Fibre Monitoring Protocol for Earthwork Activities at Brownfield Sites. https://www.claire.co.uk/projects-and-initiatives/asbestos-in-soil?start=4

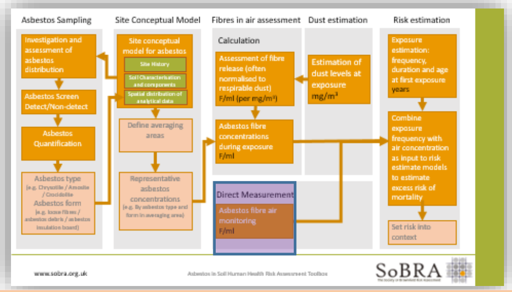
SoBRA comment: Measurement in accordance with HSG248 can result in fibres being counted but the concentration being reported as being below the method limit of quantification (typically 0.01f/ml – equivalent to 10,000 f/m^3). Below the limit of quantification does not in this case indicate an absence of asbestos fibres in air.

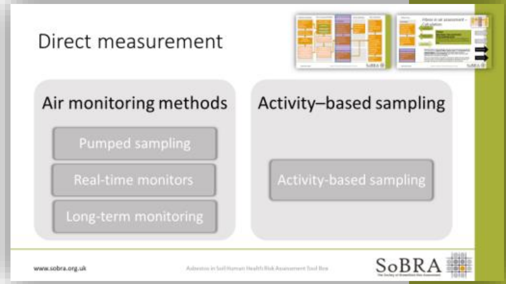
PCM alone cannot distinguish between asbestos and non-asbestos fibres (such as plant fibres). Electron microscopy analysis is required to positively confirm the presence of asbestos fibres following routine PCM evaluation if it is uncertain whether all fibres are likely to be asbestos. Duplicate sampling or splitting of sample filters is required for this. Note that because of the differing ability to identify asbestos fibres using the different microscopy techniques, measurements from each are not directly comparable.

Increasing sampling time can cause dust to obscure the filter thus preventing the counting of fibres present. The sampling approach therefore needs to be a careful balance of required limits of detection and predicted dust levels and the selection of the appropriate sampling equipment and analytical method. A protocol for air sampling is presented in the SoBRA (2015) Airborne Asbestos Fibre Monitoring Protocol for Earthwork Activities at Brownfield Sites.

Direct measurement Output

Real-time monitors





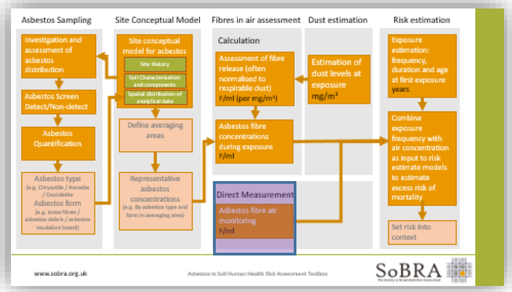
Description: Hand held real-time asbestos fibre monitors have been in development for sometime. None are in widespread commercial use but they may become a viable alternative to pumped sampling in the future.

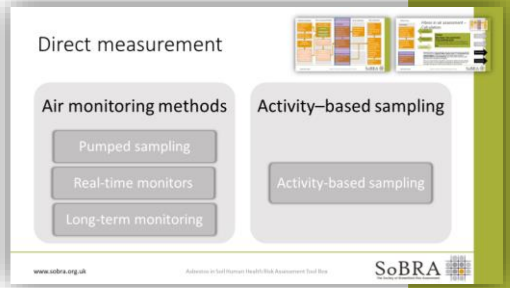
Further information: Not applicable

SoBRA comment: Not applicable

Direct measurement Output

Long term air monitoring





Description: Long term low level asbestos in air monitoring may be required in certain circumstances, depending on the outcome of the asbestos in soils risk assessment, remedial works and any regulatory requirements. Such air quality monitoring is typically for reassurance purposes and potentially may be undertaken during one or more phases of the intrusive investigation, remediation or ongoing groundworks during development. It may be undertaken on-site or off-site.

Where monitoring is not for occupational exposure purposes and is to be used to support a risk assessment for future / current site use in relation to proposed or existing developments, it may be beneficial to report to 10 f/m^3 (0.00001 f/ml) using fibre-discriminatory SEM or TEM analysis. To achieve a lower detection limit, increased sampling flow rate and volume will be required.

Further information: SoBRA (2021). Discussion Paper on Guidelines for Airborne Concentrations of Asbestos Fibres in Ambient Air: Implications for Quantitative Risk Assessment. https://sobra.org.uk/resources/reports/

Nathanail, C P, Jones, A, Ogden, R, Robertson, A (2014). Asbestos in soil and made ground: a guide to understanding and managing risks (CIRIA C733).

SoBRA Airborne Asbestos Fibre Monitoring Protocol for Earthwork Activities at Brownfield Sites. (2015). https://www.claire.co.uk/projects-and-initiatives/asbestos in-soil?start=4

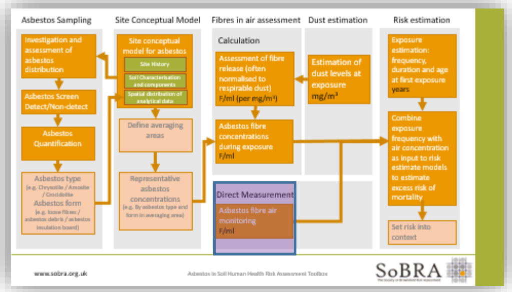
SoBRA comment: Prior to undertaking any long term air monitoring, the methodology of and rationale for the monitoring should be clearly documented, alongside the guidelines values to be used as trigger levels for any intervention. Background concentrations of asbestos in air may be required to benchmark the practicabilit of the proposed trigger levels for the monitoring.

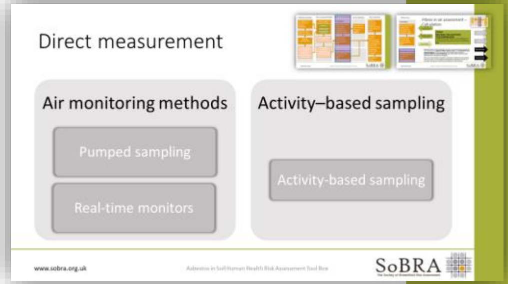
SEM and TEM analysis are more expensive than PCM (which gives a total fibre concentration rather than an asbestos fibre concentration) and currently only offered by specialist laboratories.

PCM, SEM and TEM results are not directly comparable and conversion factors are required. This is discussed in the SoBRA (2015) paper referenced above.

Direct measurement Output

Activity based sampling





Description: Activity based sampling (ABS) has the potential to be an important part of a staged approach to the assessment of health risk from the release of asbestos fibres resulting from the disturbance of ACM. It is capable of reducing the uncertainty in the estimation of fibre-release inherent in alternative theoretical approaches.

An option for ABS has been developed by SoBRA (2015). This procedure involves the raking of a minimum of 1m x 1m square of exposed bare soil using an ordinary garden rake, within a temporary enclosure secured to the ground to provide a reasonable seal. Static air samplers can be used to record airborne dust and fibre concentrations generated within the ABS enclosure whilst the raking activity is undertaken. Sampling and analysis of the soil layer being raked should be undertaken for asbestos, which may also include particle size distribution, FOC and soil moisture.

Further information:

SoBRA (2015). Design of an Activity-Based Sampling Protocol for the Testing of Asbestos Fibre Release Potential from Residential Garden Soil. https://sobra.org.uk/resources/reports/

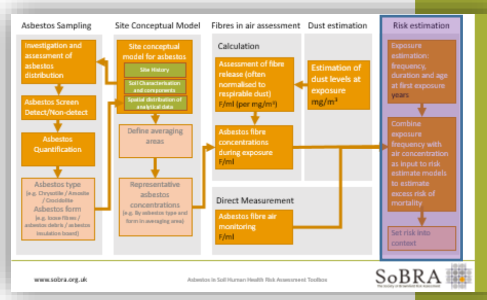
US EPA (2007). Standard Operating Procedure 2084:2007. Activity based air sampling for asbestos. https://semspub.epa.gov/work/HQ/174392.pdf

Direct measurement Output

SoBRA comment: The primary objective of the ABS protocol is to provide a reasonable worst-case estimate of current and future fibre-release and subsequent localised airborne fibre concentrations that might be possible as a result of soil disturbance. If ABS is proposed, the practical and regulatory constrains of the Control of Asbestos Regulations 2012 and any other Health and Safety requirements must be considered in advance.

The location of any ABS is important – need to be confident that soil being tested is representative of exposure model. ABS is limited to the environmental conditions encountered at the time of sampling. This can mean that reasonable worst-case conditions can be missed leading to increased uncertainty in how to interpret the results and use as a line of evidence.

A distinct advantage of ABS is the reassurance it can give to stakeholders as a line of evidence that is based on actual site conditions.



Estimation of risk

Exposure estimation: frequency, duration and age at first exposure
years

↓

Calculation of cumulative exposure
F/ml.years

↓

Estimation of risk (Excess Mortality Risk)

Fibre concentrations from Fibres in air assessment

Estimate exposure to calculate cumulative exposure from fibre concentrations during exposures

Then

Use the Hodson and Darnton model – to get excess mortality risk

Output

Excess Mortality Risk

Needs to be put in context

Exposure estimation

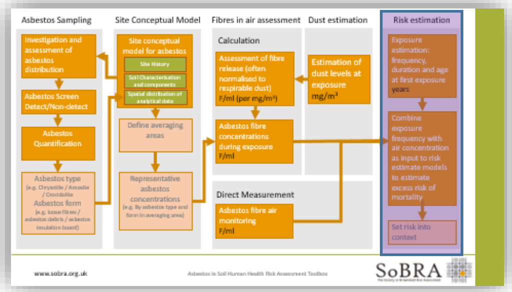
Exposure time

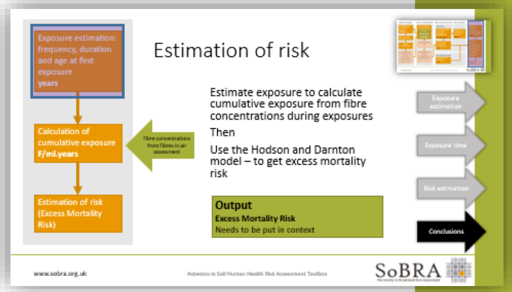
Risk estimation

Conclusions

SoBRA The Society of Brownfield Risk Assessment

Exposure estimation





Generally not measured, more likely to be modelled or assumed, though site survey may be used to determine land use scenario.

Consider number of dry dusty days from local weather data for outdoor exposure.

For indoor exposure the amount of tracked back soil should be assessed.

Define exposure scenario using either generic or site specific exposure parameters

UK Contaminated Land Exposure Assessment (CLEA) model[1] (or UK C4SL Main Report[2] or USEPA Exposure Factors Handbook (EFH)[3]) exposure duration assumptions for site scenarios

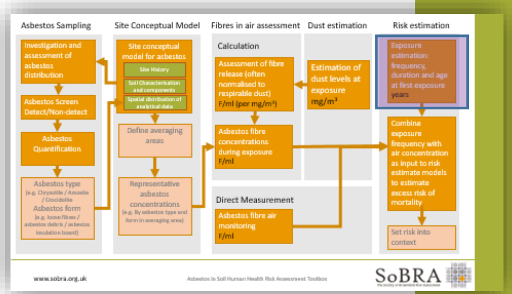
Determine likely age at first exposure

exposure frequency x exposure duration = total duration of exposure (years)
Determine for all (or highest risk) receptors and **age** at first exposure

Risk estimation

1. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/455747/LIT_10167.pdf and https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291014/scho0508bnqw-e-e.pdf
2. https://www.claire.co.uk/projects-and-initiatives/category-4-screening-levels
3. https://www.epa.gov/expobox/about-exposure-factors-handbook

Estimation of exposure time



Description: The exposure time should consider both exposure to asbestos from soil disturbance outdoors and soil dust tracked back into buildings.

The exposure should consider the age at first exposure, and the exposure frequency for each five year tranche should be based on appropriate estimate for the use being assessed.

For generic UK land uses such as residential, public open space or commercial end uses refer the C4SL Main Report or CLEA model guidance.

Further information:

Environment Agency (2009). Updated technical background to the CLEA model. Science Report: SC050021/SR3
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/291014/scho0508bnqw-e-e.pdf

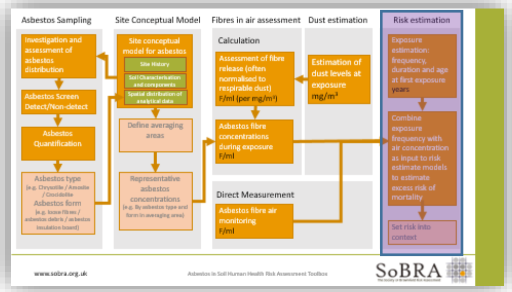
Environment Agency (2009). CLEA Software Handbook. Science Report: SC050021/SR4.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/455747/LIT_10167.pdf

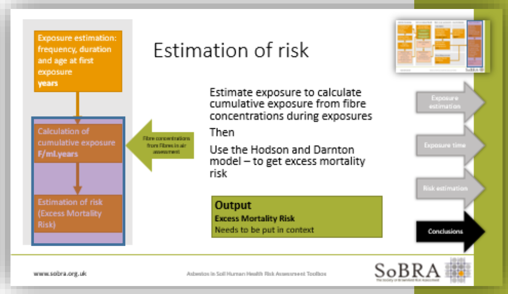
CL:AIRE (2014). SP1010 Development of Category 4 Screening Levels Main Report https://www.claire.co.uk/projects-and-initiatives/category-4-screening-levels

Exposure Output

SoBRA comment: For outdoor exposure consideration may be required of wet days when no or little dust is generated. Care should be taken to ensure that if wet days with no dust are to be considered that this is accounted for in the asbestos in air concentration used (i.e. consider time-weighted average concentration).

Risk estimation





Use exposure over time, asbestos type and age at first exposure to determine the risk of mortality.

Use Hodgson and Darnton (2000)[1] meta-analysis of multiple epidemiological studies

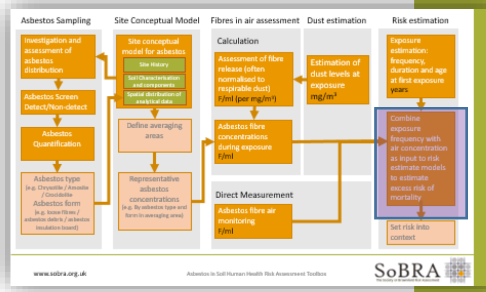
SoBRA Excel based spreadsheet tool implementing the Hodgson & Darnton algorithms is available on the SoBRA website https://sobra.org.uk/resources/reports/

Input parameters:
Cumulative exposure, asbestos type, age at first exposure
Output:
Mortality rate (e.g. 1 in a million)

Conclusions

1. Hodgson & Darnton (2000) Hodgson, J.T. and Darnton A. The quantitative risks of mesothelioma and lung cancer in relation to asbestos exposure. Annals of Occ. Hyg., Volume 44, No 8, pages 565-601.

Risk estimation from asbestos in air



Description: There are a number of models that can be used to estimate the risk to people from asbestos in air. These models consider the risks from mesothelioma and from lung cancer, and are derived based on empirical fits to epidemiological data. Differences in output often relate to how individual studies are interpreted.

These models broadly have similar inputs including:

1. The form of asbestos
2. The age of first exposure
3. The concentrations of asbestos and the exposure time and
4. The expected lifetime of the exposed individuals (to allow latency factors to be considered).

The asbestos concentrations and exposure time is generally combined to produce an cumulative exposure, however the way these are treated in each model may differ, for instance the Hodson and Darnton model applies an age adjustment factor to the cumulative exposure in each 5 year tranche.

The output is a risk. This is typically a risks of mortality rather than the risk of getting mesothelioma or lung cancer. The mortality takes into account the expected lifetime of the individual. For the lung cancer the exposed population may be important as for instance smokers have a higher risk than non-smokers.

Risk estimation Output

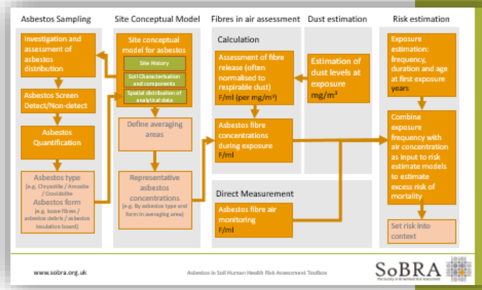
Further information: SoBRA (2021). Discussion Paper on Guidelines for Airborne Concentrations of Asbestos Fibres in Ambient Air: Implications for Quantitative Risk Assessment

SoBRA (2021). Excel calculation Sheet for risk from cumulative exposure to asbestos in air. https://sobra.org.uk/resources/reports/

SoBRA comment: The SoBRA discussion paper has adopted the linear Hodgson and Darnton model for mesothelioma and non-linear model for lung cancer. The Hodgson and Darnton model was chosen as it is the model used by the UK Health and Safety Executive (HSE).

An Excel tool has been produced by SoBRA that uses the Hodgson and Darnton model to estimate risk of mortality for each asbestos type from the data on the exposure to asbestos in air. The aim of the model is to provide a readily-available tool to users which improves consistency in calculations and avoids having to interpret and re-create the algorithms presented in the original paper.

Conclusions



The epidemiological models for asbestos provide an output defined as a mortality rate as opposed to excess lifetime cancer risk (ELCR). Direct comparison to ELCR for other scenarios is therefore not advocated, however, reference to "acceptable" ELCR may be unavoidable (e.g. that set by CL:AIRE (2014) in the development of a Low Level of Toxicological Concern (LLTC).

Conclusions from asbestos in soil HHRA should be based on an objective and balanced appraisal of all relevant lines of evidence, taking account of the stated objectives of the assessment and the level of confidence in the evidence used.

1. CL:AIRE (2014). SP1010 Development of Category 4 Screening Levels Main Report https://www.claire.co.uk/projects-and-initiatives/category-4-screening-levels

Limitations

This interactive toolbox has been developed by members of the SoBRA asbestos-in-soil sub-group acting in a voluntary capacity, and details the views of the individual members, not those of their employers. It is provided freely on the SoBRA website to help promote good practice in assessing the health risk from asbestos-contaminated soil in the UK. Users of the toolbox must satisfy themselves that the content is appropriate for the intended use and no guarantee of suitability is made.

Feedback

Feedback on this paper is welcomed and should be submitted to SoBRA at info@sobra.org.uk