HAZARDOUS WASTE SOIL TREATMENT – WORK IN PROGRESS

Where waste soil is treated in fixed plant, Best Available Techniques (BAT) apply. Relevant appropriate measures should be used, as identified in Sector Guidance EPR S5.06 “Guidance for the Recovery and Disposal of Hazardous and Non Hazardous Waste”. S5.06 gives the appropriate measures for pre-acceptance, acceptance, storage and treatment of waste as well as on emissions control.

The main aim of BAT for treatment is to ensure “operational control of the treatment process including inputs, reaction monitoring and having clear end-point objectives.” The treatment process should be well understood providing:

- process mapping and mass balance for how the treatment will proceed
- an assessment of the efficiency of the process, and
- the objectives of the treatment and where appropriate the reaction chemistry.

It is not acceptable for the chemicals used in the process to be unknown. We must be given the name, composition, function and active properties of all chemicals (even proprietary) used to treat waste. S5.06 requires:

- “details of chemical reactions and their reaction kinetics/energy balance” and
- that “the objectives and reaction chemistry should be clearly defined”.

S5.06 is also clear that **“As a general rule, no open-topped tanks, vessels or pits should be used** for storage or treatment of hazardous or liquid wastes. Exceptions would require justification in the permit application.” Mixing processes should generally be done in specifically “designed, commissioned and operated” reactor vessels or plant.

All treatment and storage must be on impermeable surface.

Contaminant	Fixed Plant requirements
Fibrous asbestos removal **Treatment is not applicable.**	Landfill is the only current option for disposing of soils contaminated by hazardous levels of asbestos fibres. Thermal treatment for example vitrification might be an option in the future but there is no plant currently installed in the UK. Hazardous wastes in landfills should fulfil the relevant WAC. Where this is not possible, seek advice regarding landfilling the waste as a Problematic Waste Stream.

Contaminant	Fixed Plant requirements
Asbestos cement removal Fibrous asbestos above 0.01% must not be present due to potential to produce fibres. Purpose is to pick out chunks of bonded asbestos material such as asbestos cement. **Where waste has multiple contaminants such as asbestos, metals and organic substances, asbestos cement should be removed first.**	The requirements of the Control of Asbestos Regulations should be considered by the operator – see https://www.claire.co.uk/projects-and-initiatives/asbestos-in-soil Windrow picking is not allowed. Screening cannot proceed unless the process is enclosed and asbestos fibres are abated via a HEPA filter. BAT is to use a shielded picking station with waste moving onto picking area via travelling platform. See for example http://www.vertasefli.co.uk/our-expertise/case-study/asbestos-picking-station and http://www.elqf.org/elqf/july2015/Asbestos%20Remediation%20Good%20Practice%20ELQF%20July%202015.pdf Water suppression may be used but the addition of water must be compensated for when determining whether any contaminant is considered to be fully treated during a later treatment process.  The end-point of the picking process is that there are no chunks of bonded asbestos remaining in the treated waste. This determination will need to be made by a qualified person as the asbestos cement pieces can be hard to distinguish from stone and soil particles. The waste should also be tested after the process to determine the concentration of asbestos fibres within the soil in order for assessment and classification to be carried out in accordance with technical guidance WM3. Asbestos cement removed from the soil matrix should be double bagged and the bags placed in an asbestos skip on site. Monitoring should be in place to ensure asbestos fibres are minimised.

Contaminant	Fixed Plant requirements
Biological Treatment of Hydrocarbons Purpose is to biologically degrade organic chemicals to carbon dioxide and water. The treatment should not be used to process low boiling point solvents unless plant and equipment is enclosed and abated.	 Some organic chemicals can be biologically treated; this include petroleum products, solvents and wood preservatives. Usually works on medium range organics. The treatment is unlikely to work on tars, long chain organics and chlorinated organics. Process is temperature (ideal is 10-25 ^{o}C), moisture, nutrient, pH (ideal 6-8) and oxygen dependent and these parameters need to be controlled. The waste may be covered to maintain temperature, prevent water ingress and prevent emissions. Drawing air through the mass can assist the degradation rate. The drawn air must be abated. If leachate is expected during the treatment process it should be collected and where possible recycled into the process. Additive materials can assist the process such as wood chip, compost, manures. They do this either by opening up the soil matrix to the air or by acting as growth promoters for microbes. Proprietary microbes or fungi may also be added. The addition of materials to hazardous waste soil must be explicitly authorised in the permit and the addition must be specific to the purpose of treating the waste. The process can vary between a few weeks and a few months. All treatment processes must be complete within 6 months on hazardous waste permitted facilities. Where this period is exceeded the treatment will be considered to have failed and the waste must be removed as hazardous waste. Chlorinated organics, inorganic pesticides, oxidising agents, cyanides and some metals can poison the biological process. Where the presence of these materials is expected to inhibit the treatment process other treatments should be explored either in isolation or as a pre-treatment step. The process can increase the concentration of more dangerous organic substances because they are not treated by the process whereas less hazardous organics are destroyed. This can potentially render the soil more hazardous after treatment than before. This should be considered before the treatment proceeds – the treatment pathway for all contaminants should be mapped.

Contaminant	Fixed Plant requirements
	Additions of materials must be compensated for when deciding on the final completion of the treatment process. Washing, oxidation treatments and other chemical treatments can also be used to remove hydrocarbons. See The citizen's guide to bioremediation.  Where the presence of substances (such as metals, cyanide, chlorinated organics) would affect the biological treatment (for example by poisoning the biologically active materials) then those substances should be treated prior to biological treatment. Alternatively, pre-acceptance and acceptance checks should be made to ensure that contrary substances are not received onto site.
Washing Purpose is to remove contaminants from the soil by solubilising metals into the washing liquor and / or concentrating metals / organics into a fines	The addition of materials such as water to hazardous waste soil must be explicitly authorised in the permit and the addition must be specific to the purpose of treating the waste – excess addition of water will be considered deliberate dilution and will not be allowed. The washing process generally relies on the soil having a fines fraction unless all of the contaminants are water soluble. The wash water may contain surfactants or other chemicals to aid the removal process. Each chemical used should be clearly identified and its use explained.

Contaminant	Fixed Plant requirements
fraction. The separated oversize, sand and gravel fractions are expected to contain little or no contamination but this must be verified.	The soil may be screened before treatment. Oversize materials must be analysed to ensure they are not hazardous if the input material was hazardous. Treatment liquors will contain the washing solution and fines from the soil. These may be treated on site and this process including any pH adjustment or filter pressing must be permitted. The water fines and / or filter cake are expected to contain the contaminants. Any hazard assessment of any fraction should compensate for the additions to the process such as the water and any additives. The assessment and classification of these wastes must be undertaken in accordance with technical guidance WM3 See The citizen's guide to soil washing.
Addition of lime, cement, lime-substitutes, cement-substitutes and other binders – stabilisation, solidification, fixation, etc. Purpose is to fix metals into the soil so that they are less soluble. Usually used to lower the solubility of metals that can influence WAC assessments. The process can also absorb water in sludge	Treatment using alkaline materials can do one or more of the following: • dry up wet sludges to enable handling • solidify soils to prevent water ingress • adjust the pH of an acidic soil to neutralise it • adjust the pH of any soil to raise its pH to a point where the metals within it are at their overall lowest solubility to affect the waste acceptance criteria for landfill. (Note this is a reversible action as over time CO_2 in the atmosphere and rainwater will lower the pH). The adjustment to the right pH can be difficult to achieve (see below). A pH range of 8-10 is usually required. Exceeding pH 10 can have adverse consequences for leaching behaviour. The treatment process requires thorough mixing. If thorough mixing is not achieved there will be hotspots of the binder in the mix which will have elevated (and hazardous) pH and the treatment will not be as effective. Mixing of soils with other wastes or non-wastes must be performed within purpose designed treatment vessels that can control any potential emissions. Where an acidic soil (usually pH 4 or less) is treated by virgin lime or cement and the untreated soil is not hazardous by metal or other substances, if the addition of the binder is controlled sufficiently the treated output might be non-hazardous – an assessment will need to be made to confirm this. Where: • an acidic soil (usually pH 4 or less) is treated by waste binders such as cement kiln dust (CKD) or cement bypass dust (BPD); and • the untreated soil is not originally hazardous by metal or other substances contamination; and

Contaminant	Fixed Plant requirements
	• the CKD or BPD used are only hazardous by virtue of alkalinity the treated output might be non-hazardous – an assessment undertaken in accordance with technical guidance WM3 will need to be made to confirm this. All other treated soils removed from site, including those treated by cement dusts will normally be classified and coded either as: • 19 02 04* pre-mixed waste; or • 19 03 04* waste marked as hazardous, partly stabilised Both of these waste entries are absolute hazardous waste entries. The only exception is where it can be categorically determined that the metal (and other) substances in the soil or binder are converted to non-hazardous forms – this is not by concentration but by actual chemical form. The wastes may then be coded under sub-chapter 19 13 entries. For example if the lead substances concentration in a waste soil are above 2,500 ppm, the addition of binder cannot change the lead substance into a non-dangerous form and any lowering of the concentration of the metal is by dilution – the output of the process must be hazardous. By modelling the process and following the reaction chemistry of each metal substance both in the soil and the binder an assessment can be made as to whether the treatment changes all the substances in the waste to non-hazardous forms. The default position for binder addition is hazardous waste output unless strictly determined otherwise. In all cases the mixing of the binder with hazardous waste soil must have a purpose other than simply dilution. See The citizen's guide to solidification and stabilisation
Chemical oxidation or reduction Purpose to destroy contaminants by	BAT required under permitting and HWR. The purpose of the treatment is to change hazardous substances in the waste to less or non-hazardous substances. For example chromium (VI) compounds can be reduced to less hazardous chromium (III) compounds, organic materials can potentially be oxidised into carbon dioxide and water.

Contaminant	Fixed Plant requirements
accelerating their decomposition. Oxidation uses chemicals (oxidants) that use the oxygen in their chemical structure to change organic substances in the soil into CO_2 and water. Hydrogen peroxide is an example of an oxidant. Reduction exchanges electrons so that a metal's oxidation state is lowered. Some metals such as chromium are less hazardous where their substances are in their lower oxidation states – Cr (VI) substances are more hazardous than Cr (III).	The chemicals used for chemical oxidation and reduction can be particularly hazardous and their storage and use need careful control. Their addition would not normally need to be compensated for as they should usually all be reacted in the treatment process. It is important however that the addition of oxidative or reductive chemicals is kept to a minimum as they will be hazardous in their own right and where an excess is added they can make a treated waste hazardous. The reaction chemistry needs to be thoroughly understood and outlined. The treatment process requires thorough mixing. Surface treatment alone will not be effective. If thorough mixing is not achieved the treatment might not be effective. Mixing must be within purpose designed vessels. Significant heat and gases can be released during mixing so process control is important. Emissions need to be managed. See The citizen's guide to in situ chemical oxidation and The citizen's guide to in situ chemical reduction
Ion exchange Ion exchange resins swap problematic cations or anions for less problematic ones. For example, water hardness is caused by calcium or magnesium cations which	BAT required under permitting and HWR. Soils can be treated using ion exchange treatment. Usually the problem ionic substances (both cations and anions), where they are soluble, are washed out from the soil into solution and passed through the exchanger where they are removed by being swapped with other ions. The problem ions remain in the ion exchange resin and when spent the resin can be sent for disposal or recharge. The soil can be tested as hazardous following the washing process but must consider the dilution by the water added. Since washing removes only the soluble substances, the non-soluble substances will not benefit from this treatment. Other chemicals (for example acids or detergents) can be added to increase the solubility of the metals allowing them to be treated by the exchange resin.

Contaminant	Fixed Plant requirements
precipitate out of solution when water is heated. The treatment process exchanges these ions for sodium. The calcium or magnesium ions remain in the ion exchange resin and the sodium ions pass through. Sodium ions do not precipitate out of solution as solids when water is heated.	Where ion exchange compounds are added to soil they may swap ions with problem ions but the problem ions whilst in another form are still present in the soil matrix. Unless the new substance formed is proved to be non-hazardous, the hazardous nature of the cation remains in the soil and the soil will be hazardous. Proof that the ion exchange treatment has produced a non-hazardous substance must be shown via the proposed reaction chemistry and by testing. Any dilution by the ion exchange material addition must be compensated for when deciding whether the treated soil is hazardous or not. Solid based ion exchange treatment has been mooted but the issue is with putting the ion exchange resin in contact with the whole mass of the soil as each individual soil particle would need to be in contact with ion exchange head for all the metals to be exchanged out of the soil matrix. Further evidence would be needed to show it was a viable technique. Some resin exchangers do not use ion exchange, instead they can selectively adsorb hazardous substances either by polar (ionic) or non-polar attraction. It is important to understand the mechanism of the treatment process to assure its validity. Adsorption treatments can include pre-treatment for example solvent washing of the soil followed by passing the liquors through the resin exchanger. The ion exchange material once spent may be hazardous waste. An assessment and classification of this wastes must be undertaken in accordance with technical guidance WM3 to determine this See: http://www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments/i
Thermal desorption Thermal desorption uses heating the soil so that organic materials leave the soil matrix allowing their recovery or destruction. The desorbed soil matrix is then potentially clear of hazardous organic substances.	See guide on thermal desorption on gov.uk. BAT required under permitting.
Other techniques	See right for other treatment techniques. Other techniques are not usually performed off-site.

Contaminant	Fixed Plant requirements
Mixing hazardous soils with other materials including non-hazardous soils The reclassification of hazardous waste as non-hazardous waste may not be achieved by diluting or mixing the waste with the aim of lowering the initial concentrations of hazardous substances to a level below the thresholds for defining waste as hazardous. Mixing hazardous waste with any other material must be permitted and the treatment must be BAT and not lead to an increase in adverse impact of the waste management on human health or the environment.	Hazardous waste must be effectively treated. Hazardous waste soils **must not be diluted**. Mixing hazardous waste soil with non-waste soil or non-hazardous soil is **not an acceptable treatment**. It will be considered dilution and the mixing will be illegal. Additionally mixing hazardous wastes with different contaminants will lead to dilution. For example, batches of soils that are hazardous due to hydrocarbons must not be mixed with soils hazardous due to metal concentration because the treatment methods are different. Soils hazardous due to one metal should not be mixed with soils hazardous due to another metal unless the treatment applies to both metals, and the dilution effects of mixing the soils is compensated for when determining that the treatment was successful. All mixing of hazardous waste soil must have a purpose beyond dilution, for example the addition of water for soil washing or the addition of oxidants for oxidation treatment. The treatment must be clearly defined and shown not to be dilution or compensated for. This is especially important where the treated material is considered to be non-hazardous or end of waste. Where mixing/blending has taken place, that dilutes contaminants, and where the waste is not subject to further treatment that compensates for this dilution factor), • the mixed material legally remains a hazardous waste (irrespective of contaminant concentrations in the mixed material), • the treated soil is likely to remain a waste (as contaminants are diluted rather than removed), • the treatment process is unlikely to be considered BAT (as the process does not treat/remove the contaminants and increases the amount of hazardous waste that requires management)

Compensating for additional materials added during treatment

Consider for example a 6,000 kg pile of contaminated soil containing which contains asbestos cement, 5000 ppm dangerous organic substances (simplified consider a 1,000 ppm hazardous waste limit) and 2800 ppm of a dangerous metal substance (2,500 ppm hazardous waste limit). During the treatment process 300 kg of water are used to suppress asbestos fibre release (20 kg cement asbestos is removed) and 600 kg of woodchip was added during the organic treatment phase. The addition of 900 kg of

materials to the soil will have diluted the metal substance to below the hazardous waste threshold – this is not considered incidental dilution. The water and wood chip materials added must be compensated for.

The asbestos removal process added 300 kg to the mass but removed 20 kg. The biological treatment added another 600 kg.

The metal concentration in the waste with the asbestos removed (compensating for the addition of the water) would be:

2,800 * 6,000 / 5,980 = 2809 ppm

At the end of the biological process the metal concentration is diluted to:

2,800 * 6,000 / 6,880 = 2442 ppm

The reduction of the metal substance from the additional water and woodchip is (2809-2442)/2809 x 100% or 13.1%. If the waste is sent for disposal after the biological treatment it would still be hazardous because not the metals in the waste have been treated other than by dilution. Any follow-up treatment must compensate for the additional materials added.

Additional treatment must be used to treat the soil if the desired end point is non-hazardous. Any hazardous waste thresholds must be compensated for by at least 13%.

For soil washing any dilution of contaminants including by the water added during the treatment process must be compensated for within all of the outputs of the washing treatment including in any treated sludge (it is expected that at least one output of a hazardous waste soil washing process will be hazardous).

Pre-acceptance and acceptance measures for soils

Pre-acceptance: the site investigation report will identify contaminants and hotspots. Each separately identified hazardous waste soil area (which will make up batches of soil waste) should be pre-accepted on the basis of the report.

Acceptance: the first load of batches of similar soil waste (as identified by the site investigation report) should be assessed. Where the site investigation report identified that the waste is hazardous, the acceptance load sample should not be used to reclassify the soil as non-hazardous. Where the load contains unexpected contaminants that would affect treatment the load must be rejected. Where the first load meets expectations, 10% of other received loads should be sampled and analysed. Where any load does not meet acceptance criteria each subsequent load must be sampled until it is determined that the batches meet expectations.

Using Waste Acceptance Criteria to determine if a waste is hazardous

Waste acceptance criteria are used to determine if a hazardous or non-hazardous waste is fit to be landfilled at a specific type of landfill (for example hazardous waste landfill, stable non-reactive waste landfill cell, inert landfill). It does not determine the hazardous or non-hazardous status of a waste. WAC testing must be used only for the purpose for which it was designated and not

to determine whether a waste is hazardous or not. An assessment of hazardous waste must follow the rules set out in WM3 Hazardous Waste: Interpretation of the definition and classification of hazardous waste.

Emissions control

‘emission’ means the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the installation into air, water or land.

‘best available techniques’ means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole.

A soil treatment process should not cause pollution to the environment or harm to human health. Asbestos picking for example should be a low risk activity because the process should be controlled so that asbestos emissions are essentially zero. Water from soil washing should not be allowed to enter a water course, and can only be discharged to sewer where the sewer undertaker authorises it. This will probably require the operator to pre-treat the washings. Biological treatment should not give rise to odours or fugitive emissions of organics. The treatment process must channel any potential fugitive emission to a point source and hence to a well-maintained abatement system. There should be no dust emissions from a soil treatment. The emissions control starts at the storage stage. If the soil can give rise to any fugitive emissions at any stage including initial storage, pre-treatment, treatment or post-treatment storage these must be controlled.

End of Waste for treated soils

End of Waste for treated soils are complex and must be determined on a case specific basis. It must consider a number of different factors including identifying a suitable product specification and comparator material. ~~REACH rules mean that a soil containing asbestos cannot be re-used.~~

Other References

https://frtr.gov/matrix2/top_page.html