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treatability bulletin

CL:AIRE Treatability Bulletins describe the key factors to be considered in the early stages of designing a remediation project. Treatability studies provide a means of determining, through laboratory- or pilot-scale tests, the practicability and likely effectiveness of remediation, and can be an essential part of a remediation options appraisal.

Soil Washing

Technology Description

Soil washing has developed from the mineral processing industry and hence uses equipment which has been adapted from this industry, specifically sand and gravel washing, coal washing, industrial mineral separation and hydrometallurgical extraction.

Most soil washing processes are based on volume reduction/waste minimisation treatment processes in which soil particles that "host" the majority of the contamination are separated from the bulk soil fractions. This separation is carried out in a series of aqueous treatment steps.

The contaminant-rich fractions may then be further treated by chemical, thermal or biological processes or sent for appropriate disposal. By removing the majority of the contamination from the soil, the bulk fraction that remains can be recycled on the site, used on another site as fill, or disposed of as less hazardous material.

Soil washing based on the separation of soil particles works via the exploitation of differences between physical properties such as grain size, settling velocity, specific gravity, surface chemical behaviour and magnetic properties. In most soil washing plants the fine fraction from the soil contains the majority of the contamination. However some types of coarser fractions can also contain contamination which needs to be removed so that the clean-up target can be met.

Another less commonly used type of soil washing involves chemical extraction stages which transfer contaminants from the soil into solution. The solution is then treated to remove the contaminants in a concentrated solid form.

Consideration of the costs of soil washing suggests that small volumes or material with a high content of fine material may be uneconomic to treat. Additional costs may be incurred for contaminant depleted fractions that do not meet the required remediation standard, and therefore require further treatment or disposal, and where a water processing unit is likely to be required.

A preliminary assessment of treatment of soils by soil washing involves carrying out a number of relatively simple laboratory treatability tests on kilogram quantities of soil (see below). The costs of simple treatability tests are relatively low cost (being mainly dependent on the number of samples treated and the cost of analysis).

In some cases, these preliminary tests will be followed by pilot-scale tests where tonnage quantities of soil are processed in smaller scale soil washing equipment, or are processed as a "batch" in an existing commercial operation. Consequently, the cost of pilot-scale tests on tonnage quantities are significantly more expensive than simple laboratory treatability tests. However, pilot-scale testing reduces the risk of failure of processing thousands of tonnes of soil in full-scale operation. Pilot-scale testing also gives an insight into potential difficulties in materials handling and solids dewatering.

Treatability Testing

The objectives of treatability testing are to:

- Evaluate the potential to separate a bulk clean fraction from a contaminated minority fraction (in terms of meeting remediation targets, and the target for recovering clean-material);
- Evaluate potential separation techniques;
- Assess the need for chemical extraction/leaching;
- Consider the requirements for dewatering the fine fractions.

A thorough understanding of the soil to be treated is needed before designing treatability tests, which will come from an appropriate characterisation of the site soil (see Box 1).

Box 1. Importance of site and feedstock characterisation

It is essential that the soil to be tested is fully characterised before the tests are started, and that the remediation criteria for assessing the effectiveness of the treatment are understood.

Where the soils on a site are relatively diverse in type and where the contamination levels vary widely, it is important that the treatability tests are carried out on sufficient numbers of samples to be representative of the contamination problem across the site.

The applicability of soil washing to different contaminant categories and ground material types is presented in Table 1.

Initial treatability tests may have an outcome based on a simple question such as "is soil washing likely to work or not?" Later tests may be designed to establish the optimum operating parameters for particle separation or contaminant dissolution. If the outcome of the treatability tests is that soil washing is not suitable (i.e. unlikely to meet the remediation criteria), then the next step is to return to the options appraisal.

Table 1: Generic applicability of soil washing to contaminants and ground materials (Defra, 2010). Key: Usually or potentially applicable Y; May be applicable ?; Not applicable N.

Organic		Inorganic		Materials	
Halogenated VOCs	Y	Metals	Y	Gravel >2mm	Y
Halogenated SVOCs	Y	Radionuclides	Y	Sand 0.06-2mm	Y
Non-halogenated VOCs	Y	Corrosives	?	Silt 2-60µm	?
Non-halogenated SVOCs	Y	Cyanides	?	Clay <2µm	?
Organic corrosives	?	Asbestos	?	Peat	?
Organic cyanides	?				
PCBs	Y	Miscellaneous			
Pesticides/herbicides	Y	Explosives	?		
Dioxins/furans	?				

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Particle Separation Tests

Tests for evaluating particle separation techniques use laboratory equipment to segregate fractions of the soil based on differences in:

- Grain size - wet sieving through a number of screens (example shown in Table 2).
- Settling velocity - hydrocycloning or cyclosizing with laboratory units.
- Specific gravity - float and sink tests using liquids of different densities.
- Surface chemical properties - laboratory froth flotation tests.
- Magnetic properties - separation at different magnetic field strengths.

The effects of removing surface coatings from particles which are otherwise "clean" can also be evaluated using laboratory abrasion/attrition scrubbing equipment.

Table 2: Distribution of different particle sizes and associated contamination levels (total petroleum hydrocarbons in this case) showing that the majority of the contamination is contained in the finest size fraction, which is 15% of the weight.

Size (mm)	Weight (%)	TPH (mg/kg)
>10.0	21	140
2.0-10.0	14	190
0.30-2.0	22	184
0.063-0.30	16	114
0.038-0.063	5	150
0.010-0.038	7	190
<0.010	15	9474

Contaminant Dissolution, Solubilisation or Leaching Tests

Contaminant dissolution tests involve extracting the contaminants from the soil with different concentrations of acids, alkalis, complexants, solvents and surfactants. The tests should not only assess how much of the contaminant is transferred into an aqueous phase, but should also aim to assess how much of the soil components themselves dissolve.

Ideally a reagent should selectively dissolve the contaminants with the minimum dissolution of the soil components, because a significant dissolution of soil components will substantially add to the cost of the treatment of the aqueous phase.

In these tests, either the whole soil below a certain size range (e.g. 2 mm) or fractions from grain size separation tests are reacted with the reagents. The resulting soil is then analysed to see whether it reaches the remediation target.

Also, the recovery of the contaminant from the leachant should be tested e.g. by ion exchange, activated carbon, precipitation, solvent extraction, etc.

Dewatering Assessment of the of fine fraction (sludge)

Whilst the coarser fractions of soil are generally readily dewatered, the fine fraction is more problematic – particularly as the fines in the treatment process tend to settle slowly from aqueous suspension, and when settled and filtered tend to retain moisture. As the fine fraction is generally contaminated, it is important to reduce the amount of the associated moisture in order to reduce the quantity of material requiring disposal. The following tests can therefore be carried out as part of treatability studies:

- With the finest fractions from laboratory grain size separation tests, a number of coagulants and flocculants can be used to ascertain settling times/sedimentation rate.
- With solids settled by a range of coagulants/flocculants, a laboratory bench-scale vacuum or pressure filter rig can be used to determine dewatering efficiency and the moisture content of the filter cake.
- Volume reduction potential should be assessed with respect to the likely mass of material going to disposal (inclusive of moisture).
- Filter cake quality (handlability etc) should be tested to ensure it meets the disposal requirements.

Box 2. Health and safety

As always, health and safety issues need to be carefully considered particularly if the treatability studies are at pilot/field scale. Potentially "significant" health and safety issues include working with hazardous materials, consideration of discharges before treatment is carried out and consideration of PPE when carrying out tests.

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