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lime remediation using quicklime

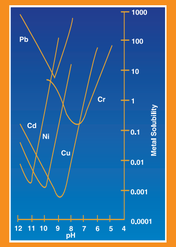
Introduction

Contamination of land can take many forms, from solid items such as old boots and shopping trolleys, to land containing chemicals such as acids and heavy metals. Contaminated land will often give rise to contaminated effluent or oily run off water and sludges.

In the chemical industry lime is one of the major chemicals used for environmental treatment of waste materials. The ability of lime to neutralise acids and react with heavy metals and many soluble impurities, rendering them insoluble, is well recognised. The use of lime to remediate contaminated sites combines this technology with equally established Civil Engineering techniques of ground improvement and stabilisation. It is known as stabilisation /solidification (S/S).

As can be seen from the data below(1), lime can effectively precipitate many metals and other contaminants.

Fig 1 A Graph of Metal Solubility vs. pH



Anion	Optimum pH for precipitation	Residual concentration in mg/l after lime precipitation	Statutory limits mg/l in Europe	Special features
Al^{3+}	5.0	<2	<3	Amphoteric above pH 8.0
Cu^{2+}	7.5	0.07	0.5	
Cr^{3+}	9.5	0.3	0.5	Amphoteric, formation of hexahydroxochromite above pH 9.5
Fe^{3+}	>3.0	<2	<100	
Fe^{2+}	>5.5	<2	<100	
Zn^{2+}	9.0	0.01	2	Amphoteric, formation of tetrahydroxozincate above pH 9.5
Pb^{2+}	10.0 - 10.3	0.03	0.5	
Ni^{2+}	9.8 - 10.2	0.09	0.5	
Cd^{2+}	10.5	0.09	0.2	

Table 1 Residual Metal Ion Concentration in water which can be Achieved by means of Optimum pH Regulation(1)

Lime Remediation of Contaminated Land.

Anion	Optimum pH for precipitation	Residual concentration in mg/l after lime precipitation
SO_4^{2-}	2-4	<2000
F^-	>11	20 - 70
PO_4^{3-}	10.5	<1

Table 2 Precipitation of Anions using Lime, Optimum pH Values for Precipitation and Achievable Residual Concentrations(1)

History

Lime Stabilisation treatment of contaminated soils laden with hazardous waste is a tried and proven chemical fixation technology. Both the technology and its acceptance has progressed dramatically over a number of years as a simple, cost effective and flexible treatment method for remediation of soils and recycling them back to usable land.

Numerous contaminated sites operated by both government and private industry have been returned back to usable land using lime stabilisation treatment methods. Successful clean-up projects have been completed in the areas of soils contaminated with metal wastes, oily wastes and chemical wastes. More recently the technology has found application in ratifying harbour dredge material during the construction and improvement of channel ways (2).

A number of projects have also been carried out successfully in the UK and Europe, including remediation of the ICI Explosives site at Ardeer in Scotland (4) and at Ulverston Tannery in Cumbria (5). More details are available in the British Cement Association and British Lime Association Industry Guide [7].

Lime stabilisation technology has been evaluated in-depth by the US Environmental Protection Agency (EPA) as part of the SITE program(3) (Superfund Innovative Technology Evaluation) and now is included in their treatment matrix for best available technologies based on cost effectiveness and capital costs.

Preliminary Site Investigation

As far as possible, the preliminary site investigation should identify the different groups of materials that exist on the site and the type(s) of contamination present [7] and [8].

This investigation can be carried out by a number of consultants.

Treatment Methodology

The treatment methodology will vary depending on the nature of the contamination and the physical state of the contaminated material. In the next section we will cover the different types of wastes [7] and [8].

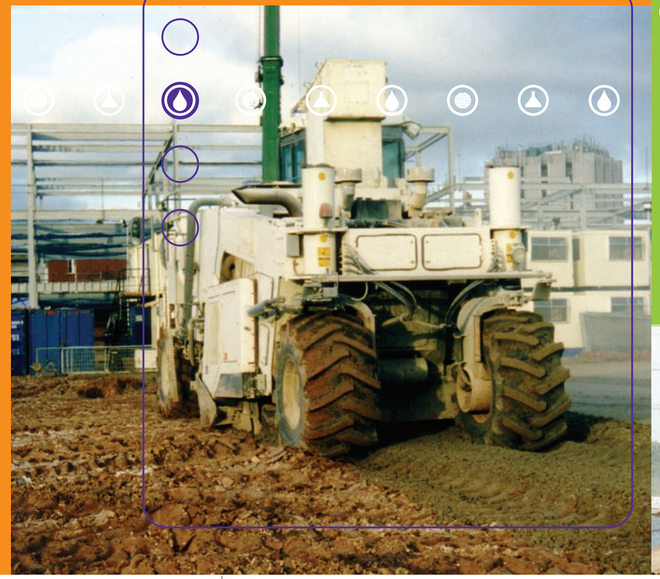
Solid Waste

Contaminated land or industrial sludge/wastes that are hazardous due to toxic contaminants, especially heavy metals are mixed with lime to form insoluble compounds, which are non-leachable. Often these sludges can be de-listed, that is, classified as non hazardous and disposed of or re-used without further regulation.

In treating hazardous wastes lime, Portland cement, fly ash, or a mixture of these materials are often used. The waste is evaluated in the laboratory, first treated with sufficient lime and then solidified with mixtures that form pozzolanic compounds. Pozzolanic compounds are mixtures of lime and materials like fly ash, which make a cementitious material when mixed together. This gives structure and strength to the treated material so it can be used as an engineering fill material or as a raw material for a recycled product.

This can often be achieved using readily available equipment, such as rotivators and piling equipment.
Rotovators - Treatment is usually undertaken on site in maximum 300mm deep layers of contaminated material. Lime is spread and mixed at the required rate.
Piling Equipment - Treatment is usually undertaken on site, using the Piling Rig to create an overlapping network of treated columns, which will either cover the area (Fig 3) or form a "protective wall" around the area.

Lime Columns - usually large diameter (>500mm) columns of lime / soil mixture.
They are installed in situ by means of a special auger that bores the hole, then as the auger is withdrawn, injects and mixes the lime (normally 7-10% by dry mass of soil) with the soil and compacts the mixture. Cement or other binder can be added where necessary.



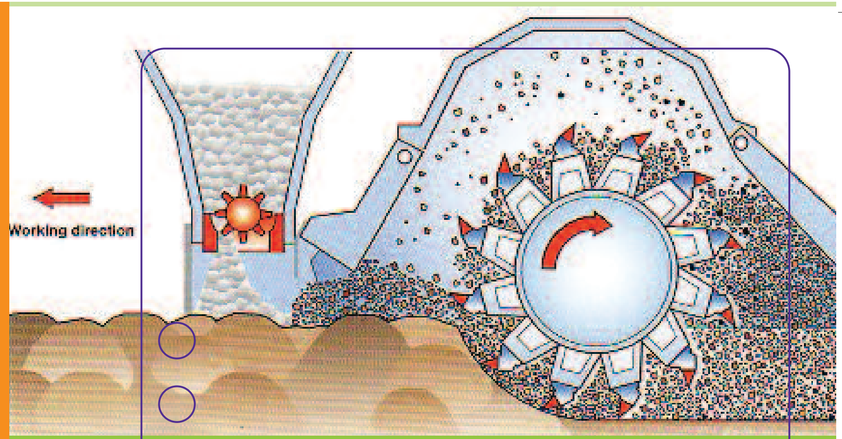
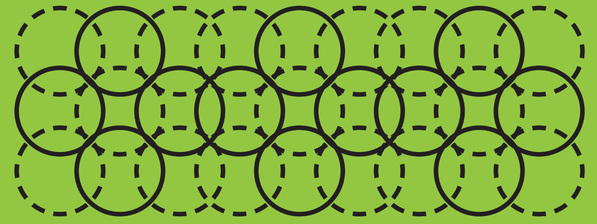


Fig 3. Contaminated "hot spots" can be remediated using an overlapping network of lime treated piles to ensure total coverage.



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Liquid Wastes

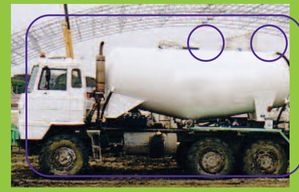
In the treatment of leachate (aqueous solutions containing chemical contamination which can include heavy metals such as lead, cadmium, zinc, copper, arsenic, etc), lime is used to adjust the pH of these solutions to precipitate insoluble hydroxides and calcium complexes of these contaminants. After filtration, the waters are safe for disposal and the sludges are chemically fixed, safe for disposal, transport and non-leachable.

Oily Wastes

Non hydrocarbon oily wastes can be successfully treated with lime to form insoluble calcium soaps, which are non-leaching, this is a non-reversible reaction called saponification (otherwise known as soap making). However, there are pitfalls that occur that one must be aware of and these can have a detrimental effect on completion of the process and rendering of the oily waste.

The addition of dry lime to an oily waste will simply soak up the water and oil but not react to form insoluble soaps. If one takes this dry treated material and compresses it, liquid will be squeezed out of the mixture. This is not yet a stabilised mixture.

To properly treat oily wastes, a lime slurry is used - and preferred temperatures around 50 to 70 degrees centigrade. At these temperatures a saponification reaction occurs quite rapidly forming Calcium soap. The saponification reaction is not reversible. If a structural material is desired, then sand or soil is mixed with the soap to give it structure. Pozzolanic materials can also be mixed with the soap/sand mixture to form a cement like material with considerable strength.



Chlorinated Hydrocarbon Wastes (PCB's, Dioxins, Pesticides, Herbicides)

For some years the US EPA has listed the use of lime as an acceptable way of solidifying and stabilising solid wastes laden with PCBs, Dioxins, Pesticides and Herbicides. It is an acceptable containment treatment method with the lime-stabilised material ultimately being incinerated (1500 - 2000 °C) at a later date(3).

Associated Uses

Lime chemistry is very useful when remediating contaminated land, but It's applications are far wider when the entire project life is considered.

Often contaminated sites can require treatment of the area to reduce moisture content and increase load bearing capacity to allow traffic movement before remediation work can commence, this can be easily achieved with lime improvement techniques(6). Treatment of any leachate to remove soluble contaminants can usually be achieved with lime.

Lime remediation of contaminated land is a simple process, which uses readily available machinery to give a cost effective solution and can be done in-situ, which reduces environmental impact.

For further details on lime remediation of contaminated land, please contact the British Lime Association on

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References

1. European Lime Association Technical Booklet. "Lime for a Clean Environment - Lime and Dolomite Products for the Treatment of Drinking Water, Waste Water and Sewage Sludge."
2. Foster S. and Robinson J. D., Singleton Birch. "Lime Remediation of contaminated soils - The Quick Fix.....ation Technology."
3. US EPA Superfund "Case Studies – available via the US EPA website www.epa.gov/ORD/SITE."
4. Wylie M. and Barker P. "Case History - Land remediation at ICI Ardeer."
5. Bleasdale B. "Remediation and ground improvement at Low Mill Tannery (Ulverston)."
6. British Lime Association Datasheet Series 1. "Earthworks improvement using Quicklime."
7. Remediation of Brownfield Land. Cement and Lime Industry Publication.
8. Environment Agency and CASSST - "Guidance on the stabilisation/solidification for the treatment of contaminated land."

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The British Lime Association is one of the constituent bodies of the Quarry Products Association, the trade association for the aggregate, asphalt and ready-mixed concrete industries.

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