TECHNICAL GUIDANCE DOCUMENT

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

Ex-Situ Treatment of Dense Non-Aqueous Phase Liquids Using Calcium Oxide (Quick Lime)

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Notice

The Technology Evaluation Work Group completed this evaluation of Ex-Situ Treatment of Dense Non-Aqueous Phase Liquids Using Calcium Oxide (Quick Lime) based on professional expertise and review of items listed in the "References" section of this document. The criteria for performing the evaluation are generally described in the IDEM OLQ technical memorandum, *Submittal Guidance for Evaluation of Innovative Remediation Technologies*.

This evaluation does not approve this technology nor does it verify its effectiveness in conditions not identified here. Mention of trade names or commercial products does not constitute endorsement or recommendation by the IDEM for use.

Background

Calcium Oxide (CaO, Quick Lime) is a white crystalline solid manufactured by heating limestone, dolomite, coral, oyster shells, or chalk (which are all mainly calcium carbonate, $CaCO_3$) to drive off carbon dioxide. Quick Lime is used in the construction industry for soil drying, modification, and stabilization. Quick Lime reacts with water to produce heat according to the following reaction:

$$CaO + H_2O \rightarrow Ca(OH)_2 + \text{Heat}$$

When applied to wet soils, the reaction consumes approximately 30% water by weight and provides dry solids for stability.

The case-study provided for review (Dean, 2003) discussed the use of Quick Lime for the ex-situ treatment of Dense, Non-Aqueous Phase Liquids (DNAPLs) – specifically TCE and 1,1,1 TCA – in soils at a site in Florida. The original plan for the site called for ex-situ vacuum extraction of all contaminated soils. Quick Lime was added to the soils at an approximate 5% ratio to improve the soil handling characteristics during removal. Project managers observed that the mixing with Quick Lime caused a reaction which reduced contaminants to below the leachability soil cleanup target levels. Approximately 11,500 cubic yards of soil were eventually treated with Quick Lime and returned to the excavation after verification sample results showed treatment goals had been met.

One conclusion of the case-study is that Quick Lime may likewise be used effectively for treatment of DNAPLs in soils at other similar sites. After reviewing the case-study and consulting additional sources (listed in references section), the following summary comments were compiled.

Advantages

From an environmental standpoint, Quick Lime is benign. Quick Lime is frequently used in water treatment operations and in agriculture when pH control is needed.

Cost: For the Florida case-study provided, an estimated savings of $2.5 - $3 million was realized when compared to off-site transport and disposal. Quick Lime is not a specialty chemical, and is readily available and relatively easy to obtain and manage in bulk.

A study in the United Kingdom (Schifano, 2006) showed that "significant decreases in concentrations of petroleum hydrocarbon compounds were measured in soils and leachates upon quick lime mixing."

Physical properties of the soils are favorably changed by Quick Lime treatment in many cases. Lime reacts with medium, moderately fine and fine-grained soils to produce decreased plasticity, increased workability, reduced swelling, and increased strength.

The addition of Quick Lime may be used to adjust the pH of soils to a level where metals contaminants are least likely to leach. However, the long-term stability of this method and the effects of pH change by Quick Lime on the leachability of some metals are currently not well understood.

Limitations

Field demonstrations have not successfully identified the dominant mechanism responsible for the reduction in DNAPL concentrations in Quick Lime treated soils. Possible reactions include:

- Volatilization of the DNAPLs as a result of the increased temperature occurring during Quick Lime addition.
- Enhanced abiotic destruction of the chemicals resulting from an increase in temperature.
- Entrapment of the contaminants in the soil – $Ca(OH)_2$ matrix.

Likewise, a United Kingdom study (Schifano, 2006) concluded:

- The increase in temperature due to the exothermic hydration reaction of quicklime when in contact with porewater helps to volatilize the light compounds but may not be entirely responsible for their concentration decreases and for the decrease of heavy aliphatics and aromatics concentrations.

Other unknowns are the resulting byproducts of conversion, their mobility and toxicity, the disposition of the treated soil for disposal, and the impacts of the treatment on the microbial populations present in the soil.

Due to the above unknowns, additional research is needed before Quick Lime treatment can be considered a reliable, cost-effective remediation process for soils.

Problems Encountered

No major problems encountered in references reviewed.

Safety Issues

Quick Lime will react with any moisture, including sweat, eyes and lung tissue, so adequate PPE is essential. Quick Lime is incompatible with many organics, halogens, acids, and combustible materials. Standard safety procedures should be applied.

Indiana Case Studies (or use in similar environment)

Quick Lime has been and is currently being used – either alone or in combination with other treatments – for treatment of DNAPLs and other contaminants in soils at Indiana sites. However, no detailed case studies for Indiana were available at the time this memorandum was prepared. Although the Florida case-study provided appeared to show that Quick Lime was useful for ex-situ treatment of DNAPLs at a particular site, it cannot be concluded that the treatment would work at a similar site in Indiana. The dominant mechanism for the reaction between Quick Lime and the contaminants has not been determined. Since Indiana site conditions may vary considerably from those at the Florida site, the effect of these variations on the treatment process cannot be accurately predicted.

Conclusion

Quick Lime appears to be an effective, low-cost product for ex-situ treatment of DNAPL contamination in soils. However, very few case-studies for this treatment process were available, and no Indiana case-studies were located. Additional research is needed to determine

- The dominant mechanism for contaminant reductions due to the treatment,
- A list of contaminants for which the treatment is effective,
- Necessary site conditions for the treatment to be effective,
- Appropriate and cost-effective mixing procedures and amounts of Quick Lime needed for treatment, and
- Regulatory guidance for post-treatment monitoring.

Until more information on this treatment has been evaluated, Quick Lime must be seen as experimental only.

Further Information

If you have any additional information regarding this technology or any questions about the evaluation, please contact Jim Risch, Environmental Chemist, at (317) 233-6541 or by e-mail at jrisch@idem.in.gov. This technical guidance document will be updated periodically or if new information is acquired.

References

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