The use of lime (CaO) and limestone ($CaCO_3$) as a stabilization process applied to Arsenic contaminated soil around abandoned mines

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The main objective of stabilization process was to reduce leaching rate of heavy metals passing through soil to surface water or groundwater. Pilot scale column experiments were performed to investigate the efficiency of lime and limestone as the immobilizing amendment to reduce As leaching from the contaminated soil to the surrounding water. For As contaminated soil, surface soils were collected at around the farmland connected to the Samkwang abandoned mine, Korea and its initial As concentration was 40.99 mg/kg. For a physical model for the genuine contaminated soil leaching As, an acryl column (15 cm in diameter and 100 cm in height), which of the upper and lower part consist of dense lattice screen plates and the drain system for injection and extraction of artificial rainfall, was designed. As the mixing treatment process for the stabilization, 1 and 2 w.t.% of granulated lime or 2 and 5 w.t.% of granulated limestone were mixed with the contaminated soil and they were packed in the arcyl column. From the top of the column, at every 24 hr, 1092 ml of artificial rain (50 % of average yearly rainfall) was uniformly sprayed on the top of the column at the constant rate of 100 ml/min for twenty days, representing 20 year of soil leaching in the real farmland. Leached water was drained from the bottom of the column and its As concentration was analyzed on ICP/MS (Perkin elmer, Elan 6100) to investigate the decrease of leaching amount by lime and limestone. From the result of experiments, for 1 and 2 w.t.% of lime, As concentration of leached water decreased by 95 and 96 %, respectively. For 2 and 5 w.t.% of limestone, As concentration of leached water decreased by 92 and 76 %, respectively. For mixing 1 w.t.% of granulated lime and 2 w.t.% of granulated limestone, As concentration of leached water decreased by 96 %, suggesting that lime and limestone are very useful to decrease As leaching from the contaminated soil.

Pilot scale experiment for the *in situ* flushing coupled with high pressure air jet injection to remediate the bunker fuel oil contaminated site

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Pilot scale experiment for the *in situ* flushing coupled with high pressure air jet injection was performed to remediate bunker A and C- oil contaminated soil and groundwater. The contaminated site was located at Ulsan, Korea, which had been used as a roofing tile manufacturing facility area for 25 years. The average total petroleum hydrocarbon (TPH) concentration of soil in the site was 3449.95 mg/kg and it exceeded 6 times of the standard tolerance limit (500 mg/kg) regulated by Korean Soil Conservation Law. A pilot scale test site (15m x 19m x 6m) was selected in the contaminated area for the *in situ* flushing with high pressure air jet injection and the selected test site was mostly composed of heterogeneous sandy and gravel-sandy soils, having the 4-5m of contamination depth. Fourteen injection wells and 3 extraction wells including the trench at the right boundary of the site were built in the test site. After two percent of surfactant solution was flushed into the injection well, the high pressure air jet was injected to accelerate the mobility of flushed solution in pore spaces underground and thus to increase the removal efficiency of the *in situ* flushing.

The effluent solution was treated by the chemical treatment process including oil separator for its recycling. Water samples taken from injection and extraction wells were analyed on GC/FID (Hewlett Packard, Agilent 6890) and ICP/OES (Perkin elmer, Optima 3300XL) for TPH and heavy metal concentration, calculating the removal efficiency of the *in situ* flushing with high pressure air injection at the test site. Total 3.6 ton of TPH (about 86% of the initial TPH) was removed from the contaminated site and TPH concentration of the residual soil was below the standard tolerance limit (500 mg/kg). The optimum sulfactant solution injection rate and air jet injection rate was determined to be 11L/min and 25 kg/cm^2, respectively. Results from the pilot scale test suggested that the *in situ* flushing coupled with high pressure air jet injection has a great possibility to remediate bunker fule oil contaminated soils.