Use of $CaCO_3$ as an amendment to immobilize heavy metals from the contaminated farmland soil around abandoned mines

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Experimental method

This research focused on the soil stabilization process by using limestone ($CaCO_3$) to decrease the leaching of arsenic and other heavy metals from contaminated farmland soils around abandoned mines, Korea. Pilot scale column experiments were performed to investigate the efficiency of limestone as the immobilizing amendment to reduce the heavy metal leaching from the contaminated soil. A physical model for the genuine contaminated soil environment was designed and heavy metal leaching rates by artificial rainfall were measured in diverse treatment conditions.

An acryl column (19cm in diameter and 30cm 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 used for the column experiments. As the amendment, granulated limestone (4 ~ 6 mm in diameter) was used for the “mixing treatment” experiment. Two or 5 w.t.% of granulated limestone was well mixed with the farmland soil. At every 12 hr, 817 ml of artificial rain (33% of average monthly rain fall) was uniformly sprayed on the top of the column at the constant rate of 200 ml/min for thirty days, representing 5 year of soil leaching in the real farmland field. Discharged water was sampled from the bottom of the column at different time interval. The pH of discharged water was measured and its heavy metal leaching concentrations were analyzed on ICP/OES to calculate the accumulative mass of each heavy metal leached from the soil for 5 year.

Results and discussion

With only 2% of granulated limestone, As, Cd, and Zn leaching concentrations decreased by 53%, 97%, and 98%, respectively, compared to that without the amendment mixing and they maintained much below Korean Drinking Water Limit (KDWL) for 5 year leaching. Although 5 w.t.% of limestone was added as an amendment in the column experiments, the pH of the leaching solution slightly increased and maintained lower than 9 (mostly lower than 8), but its efficiency immobilizing heavy metals in the soil was potent. Because of low pH change, less adverse effects, and economical consideration, limestone could be more available to immobilize heavy metals from the farmland soil than lime(CaO) in the real contaminated site.

Conclusion

From the pilot scale continuous column experiments, it was investigated that the “mixing treatment” using limestone will become one of major processes to immobilize heavy metals from the contaminated soils around abandoned mines.

Influence of organics on microbial reductive dissolution of synthetic Fe-Cr oxides

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Cr speciation either as Cr(III) or Cr(VI) in subsurface environment is corresponding to its chemical state; reducing or oxidising, which is again controlled by microbial activities. Cr speciation is of environmental concern due to their different behaviour in mobility and toxicity. Amorphous and crystalline Fe-Cr oxides were synthesized using the method of Sugimoto (1992). Firstly, three different experimental settings were established using the Fe-Cr oxides under anaerobic condition; 1) Oxides + 2,6-anthrahydroquinone disulphonate (AQDS) + Iron reducing bacteria (Shewanella sp.). 2) Oxides + Iron reducing bacteria and 3) without the microbe and AQDS. The Shewanella sp. used in the experiment has been isolated and cultured from the sea clay collected in western coast in Korea. The mixture was placed in vials and were run for up to 40 days. In the experimental set mixing the synthetic oxides and the microbe, more Cr was been released from amorphous Fe-Cr oxides, compared to crystalline oxides (45.4 and 30.8mg/Kg). Addition of AQDS enhanced the mobility of Cr to 57.6 mg/kg (amorphous oxides) and 35.4 mg/kg (crystalline iron oxides), respectively. Cr concentrations increase with days but reached rather constant values in 10 (crystalline) to 20 (amorphous) days, whereas the Cr in the samples without bacteria and AQDS increase to a certain level (10 and 5 mg/Kg for amorphous and crystalline) and then decrease to 0 in 40 days. Fe(II) and Fe_{total} concentrations are corresponding to the changes in Cr released from the synthetic oxides, as well as Eh. Little Cr(VI) has been detected in all samples and the Cr speciation in the experiment is believed to exist nealy as Cr(III). Both Fe(II) and Fe_{total} were more released from amorphous oxides, compared to crystallin oxides. Humic acids are utilised as an electron shuttle in the metal-microbe-organic system. Namely, the Fe-Cr oxides are dissolved under reducing condition through interactive chains of electron shuttling involving iron reducing bacteria, AQDS and metals (Fe, Cr) in subsurface environment. This geochemical process is instrumental in remediating metal contaminated soils.

Reference

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