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Bio-toxicity Assessment of Drilling Waste Containing EDTA

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Abstract

Sodic mixtures of soil and drilling waste can meet proposed disposal thresholds for both sodium adsorption ratio (SAR) and electrical conductivity (EC) when treated with EDTA at cost-effective rates. EDTA reacts with insoluble free lime (calcite, calcium carbonate, $CaCO_3$) to form a soluble, stable Ca complex thus reducing SAR but without markedly increasing EC. Treated mixtures no longer display adverse drainage characteristics typical of sodic soil.

Results of bioassays indicate that earthworms survive in soil containing EDTA at rates required for SAR remediation (up to 1,200 mg/kg). Seedlings are less tolerant, indicating that the use of EDTA may only be feasible for waste disposal methods involving burial of the waste-soil mixture. An extract of a mixture containing 12,000 mg/kg (sic) of EDTA passed the Microtox™ bioassay, prescribed for drilling waste disposal in Alberta.

Introduction

Disposal of drilling wastes is permitted on leases in western Canada, provided the waste is mixed with at least three parts by volume of the receiving soil. A new draft directive (D-50) in Alberta (EUB, 2007) would restrict resulting increases in soil EC and SAR.

Conventional treatments for high sodicity involve adding soluble calcium salts to counter the well-known adverse effects of sodium on clay dispersion, soil structure and drainage. A side effect is an increase in soil salinity, thus making it difficult to bring SAR below the D-50 threshold without driving EC above it (Ashworth & Webster 2004), possibly hindering plant growth.

Ashworth (2007) suggested using the chelating agent ethylene diamine tetra-acetic acid (EDTA) to release soluble Ca by reaction with soil calcite, thus lowering SAR values without greatly increasing EC (thanks to the small charge-carrying ability of the Ca-EDTA complex). EDTA does not form a complex with monovalent cations. EDTA is an approved chemical that is widely used, e.g. in cosmetics, pharmaceuticals and foods; but for soil treatment the need existed to test its effects on appropriate biota.

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Materials and Methods

The soil used was a non-saline, non-sodic loamy subsoil containing 3 % free lime, from a drilling lease near Bassano, AB. Bioassays were conducted by HydroQual on springtails and earthworms in soil treated with analytical grade EDTA (acid form) at concentrations up to 7,000 mg/kg, following standard procedures for organism survival; and on northern wheatgrass and lettuce, following standard procedures for seedling emergence, and for shoot and root growth (Environment Canada 2004, 2005a & b). The Microtox™ bioassay (WCMUC, 1994) was also employed on a mixture of soil and sodic drilling waste with 12,000 mg/kg of EDTA.

Results and Discussion

Springtail survival was unaffected by EDTA at concentrations as high as 6,500 mg/kg, but earthworm bioassays indicated a no-observable effect concentration (NOEC) in the range 1,250 < NOEC < 1,625 mg/kg of EDTA, above which rate all earthworms died. They are less tolerant than springtails probably because they ingest soil particles rather than simply move amongst them. The effects of EDTA on seedling germination, and on shoot and root growth of northern wheatgrass and lettuce, are summarized in Table 1.

Table 1	**NOEC in EDTA-treated soil was:**	
Bioassay test	**greater than**	**and less than**
Springtail survival	**6,500 mg/kg**	**n/d**
Earthworm survival	**1,250**	**1,625**
Wheatgrass:		
emergence	**1,250**	**6,800**
shoot/root length	**150**	**300**
shoot/root biomass	**n/d**	**150**
Lettuce:		
emergence	**600**	**1,200**
shoot/root length	**150**	**300**
shoot/root biomass	**n/d**	**150**

n/d = not determined

It is clear from the results of these preliminary tests that EDTA can interfere with soil biota at quite modest concentrations; when absorbed by organisms it probably exerts powerful chelating effects on the micronutrient metals involved in cellular processes (Chaberek & Martell, 1959).

The concentration of EDTA in a soil-drilling waste mixture depends on (a) the rate of EDTA applied per cubic metre of waste, (b) the dry bulk density (DBD) of both the waste and the receiving soil, and (c) the soil:waste volume mix ratio (which under D-50 must be at least 3:1 but is seldom wider than 7:1 due to the difficulty of obtaining a homogeneous mixture on-site). The post-disposal concentration can be predicted using the following formula (EUB, 2007).

$$\textbf{mg EDTA/kg} = 10^6 \times \textbf{kg EDTA/m}^3 / (\textbf{mix ratio} \times \textbf{soil DBD} + \textbf{waste DBD})$$

Table 2. Effect of rate of EDTA applied & mix ratio on final concentration		
EDTA rate	**Mix ratio**	**EDTA in soil-waste mix**
5 kg/m^3	**3**	**800-1,000 mg/kg**
10	**5**	**1,000-1,200**
15	**7**	**1,100-1,300**

Table 2 summarizes estimates of mix ratios required, from the standpoint of earthworm survival after disposal of EDTA-treated waste by the mix, bury and cover option. A soil-waste mixture with a ten-fold greater EDTA concentration passed the Microtox bioassay. Judging from the results of bench-scale and pilot-scale field tests (Ashworth, 2007) rates of EDTA required for remediating high SAR are in the range 5-10 kg/m^3 of waste.

The estimated present-day cost of on-lease EDTA treatment at those rates is $ 20-40 per m^3 of drilling waste; costs of "dig & dump" disposal in the event of failing to meet D-50 criteria for SAR or EC could be 5 times higher, depending on the distance from the lease to an approved landfill site.

Literature References

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