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Characterizing Polyhalite and Comparing with Other Potassium Fertilizers

Figure 1. Polyhalite core from Zechstein deposit. Courtesy of: Sirius Minerals, Plc.

Polyhalite (POLY) means "many salts" in Greek and is an evaporate mineral of sulfates of potassium, magnesium and calcium. Polyhalite is widely formed as a constituent of marine evaporates, associated with halite (NaCl) and anhydrite ($CaSO_4$). Polyhalite (POLY) is emerging as a multi-nutrient fertilizer for crop production but data are limited regarding its solubility, nutrient availability and mobility in soil compared to other fertilizers. This study characterized POLY (figure 1) from the Zechstein deposit in the United Kingdom for solubility limit, dissolution rate, and nutrient mobility compared with muriate of potash (MOP), sulfate of potash (SOP), and sulfate of potash magnesia (SOP-M) fertilizers.

In terms of **total element conte**nt, it was determined that POLY contains 11.3 ± 0.2, 11.0 ± 2.4, 3.8 ± 0.2 and 18.5 ± 3.2 % of the K, Ca, Mg, and S, respectively, with additional nutrients required by plants: Fe, Zn, Ni, Cu, and Mn and, plus detectable quantities of trace elements in concentrations considered too low to contaminate soils.

The **salt index** (figure 2) determined for POLY was 68.5 ± 10.8, lower than muriate of potash (MOP, 128 ± 6) and sulfate of potash (SOP, 103 ± 2.2), and higher than sulfate of potash magnesia (SOPM, 49 ± 3.1).

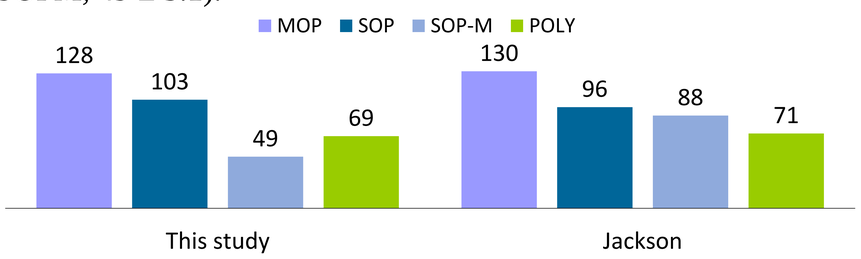

Figure 2. Salt Index comparison results from literature and this study

SGS laboratories from France determined that polyhalite from the Zechstein deposit in the UK has a **solubility** in water of 26.2 g L^{-1} at 25˚C. Differently, in this study we determined the **dissolution rate** (figure 3) for the commercial K based fertilizers in water at various stirring times. Test was conducted by adding 1g of fertilizer to 100ml of deionized water, 20ºC with continuous agitation up to 120 minutes. For POLY as well as for SOP and MOP 90% is dissolve after 45 minutes.

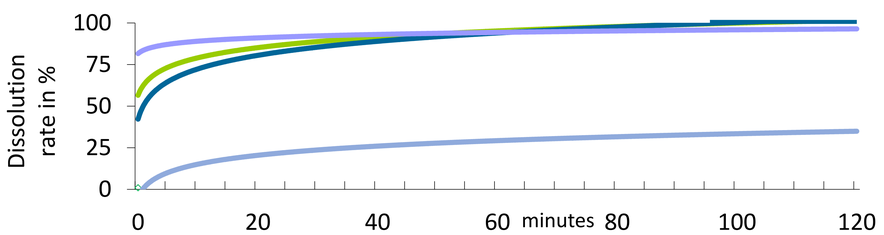

Figure 3. Dissolution rate in water at 20ºC of four potassium based fertilizer over a period of 120 minutes

Figure 4. Leaching columns

Forty five PVC pipe and couplings columns (figure 4) [(3 soils x 4 fertilizers) + 3 controls (1 per soil type)] replicated 3 times, were used in a **leaching** study. Each column was carefully packed using air dried and screened (< 2mm) soil to a height of 300 mm within the column. Each column received an equivalent rate of 61 mg of K_2O of each fertilizer type, applied to the soil surface of each column mixed into the top 10mm of soil. Prior to initiate leaching, soils·in columns were saturated by placing them in 20-liter plastic buckets containing deionized water for 24h. Each column was mounted into a rack cabinet and equipped at the bottom with a 70 mm diameter plastic funnel connected to a 250ml polyethylene bottle to collect the leachates. Water was applied to each column via a drip application at the rate of 0.22 ml s^{-1} with 117 ml of deionized water applied every 3 days for a single leaching event. Repeated over a period of 72 days to emulate two years of the average rainfall that occurred in the State of Florida for the 2008-2013 period (NOAA, 2014).

The **leaching** of K from soil columns amended with POLY occurred more rapid and higher compared to MOP, SOP, and SOPM. The leaching of SO_4 from soil columns amended with POLY were slower in sand and loamy fine sand soils but higher in loam soil compared with SOP and SOP-M. The leaching of Mg from soil columns amended with POLY was higher for POLY than for SOP-M. The leaching of Ca from soil columns amended with POLY was higher in sand soil, then in loamy fine sand and was lower in loam soil. These results suggest that POLY in soil will supply nutrients to plants in sufficient quantities compared to other K source fertilizers MOP, SOP, and SOPM (figure 5).

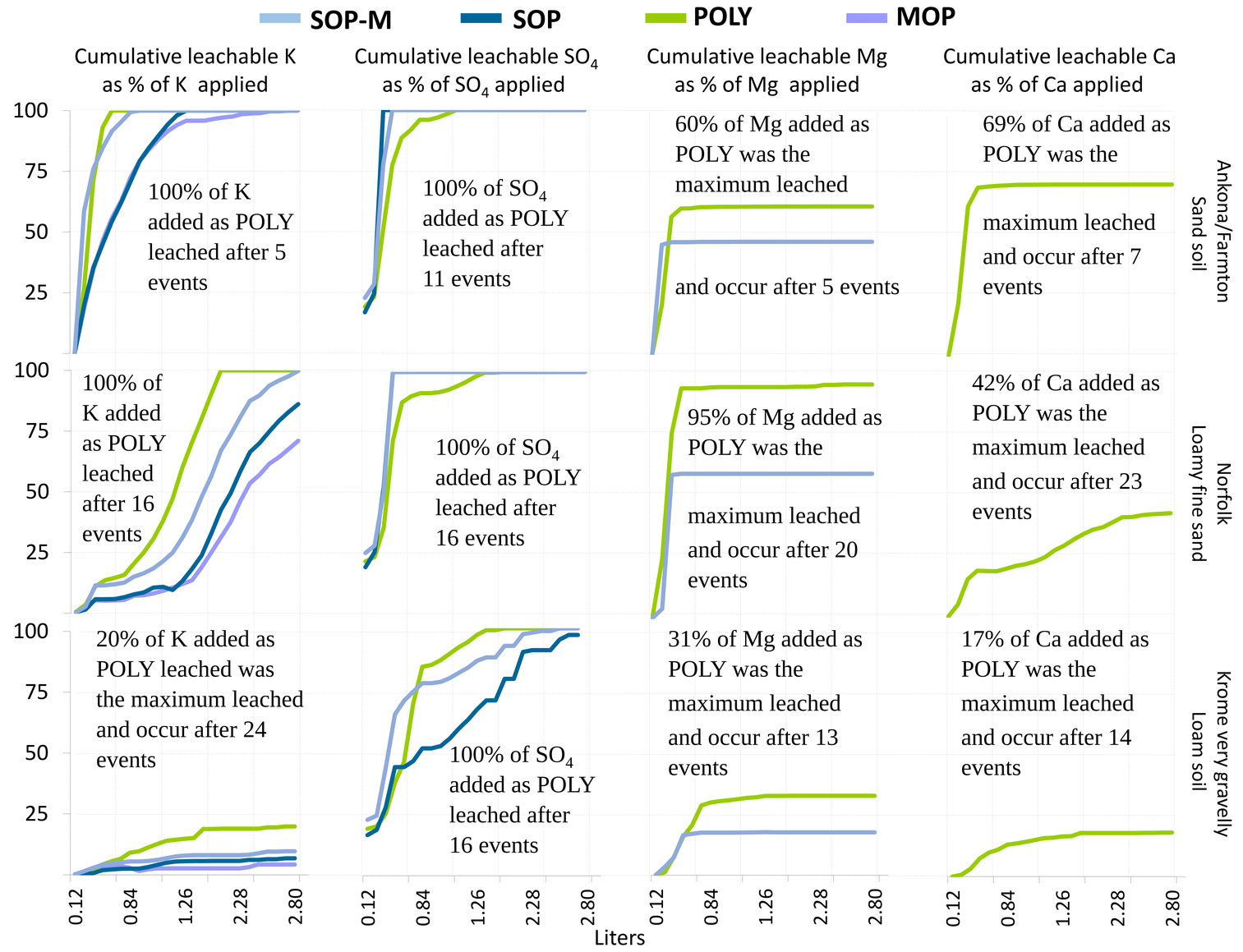

Figure 5. Cumulative leachable K, SO4, Mg and Ca as % of K, SO4, Mg and Ca applied in three different soil types.

Conclusions: Based on chemical analyses, polyhalite can be used as a multi-nutrient fertilizer containing ten nutrients essential for plants. Low salt index of polyhalite suggests that it can be applied along crop seeds without salt damage. Polyhalite solubility is lower than that of MOP and SOP, but this will not affect nutrient bioavailability to plants, since the leaching study indicated that K, Ca, Mg and SO_4 in polyhalite were more readily available than those in SOP in a loamy soil as well as in a sandy soil. Therefore, the solubility should not affect nutrient bioavailability to plants.

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