Remediation of Potash Slime Tails Through Use of Cross-Linked Polyacrylamide Hydrogel*

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1.0 Introduction

Approximately 300 million years ago, during the Pliocene series of the Tertiary period, the earth went through a substantial global cooling trend. The mean annual temperature during the Pliocene, along the coast of the pacific coast of North America, was 12 ° C (Goudie, A. 1992). Sea levels markedly lowered as the water was frozen into glaciers, and there were mass flora and fauna extinctions. Oceanic salinity levels rose as a result of the glaciers formation thereby precipitating out the ocean salts. During one of the glaciation cycles of the Pliocene, the Devonian, a great inland ocean, covering a substantial portion of northern North America, evaporated and/or was taken up by the proceeding glaciers leaving behind mass deposits of Na-K-Ca-Mg Cl salts. It is from these salts, located within the Elk Point Basin region of the Williston Basin, that potash is mined from. As the ocean filled in and dried up, it was eventually covered by more than a thousand meters of cover material. 1.2 km below the surface of the earth at Vanscoy, SK, lies a substantial deposit of potash contained within an extremely saline marine sediment. During the course of the mining and separation process, potash mine slime tails, a combination of silt (36-38%), clay (27%), and sand (10%) particles, high in Na (≅ 48,000 mg/L), K (≅ 24,000 mg/L), Ca (≅ 1,920 mg/L), Mg (≅ 110 mg/L), and carbonates (26-28%), settles out into large ponds. The pH of the marine sediment, 7.7 to 8, is neutral to slightly alkaline, however the electrical conductivity is approximately double that of sea water, easily surpassing EC values of 200 mS cm^{-1}.

Decommissioning of the potash mining sites requires that the slime tailings be reclaimed. A number of tactics have been tried to date with negligible success. In 1996 a greenhouse study using the soil amendment cross-linked polyacrylamide hydrogel (X-LPAM) was tested to determine if it could be used to create soil structure thereby allowing the slime, or marine sediment, to be leached of its high salt load. The greenhouse study indicated that the 0.2% (polymer wt./soil wt.) addition of X-LPAM was the most successful in reclamation of the sediment. Three different types of grasses (*Puccinellia distans*, *Agropyron smithii* and *trachycaulum*), were successfully germinated and grown. The 0.2% polymer treatment had the highest efficacy, and in decreasing order of efficacy, 0.3%, 0.1% and then the control with no polymer. The experiment showed that the level of SAR (Fig. 1.0), EC, and bioavailable sodium concentrations, which were originally 61, 189 mS cm^{-1}, and 2050 µg 10 cm^{-2} hr^{-1} respectively, dropped to 1, 4 mS cm^{-1}, and 41 µg 10 cm^{-2} hr^{-1} respectively, in the 0.2% (polymer wt./soil wt.) treatment. Due to these results, the decision by the potash industry, SERM, and SnF Floerger (the company

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supplying the polymer), was to try a field experiment to see if these positive results could be replicated under field conditions. For reference purposes, halophytes are capable of growing in soils with an EC of between 30 and 50 mS cm^{-1}, i.e. *Distichlis stricta* and *Salicornia rubra* respectively (Tiku, B. 1975), and SAR > 13.

A site was chosen at the Agrium mine located at Vanscoy, SK, and a raised bed was constructed in early summer 1997. Due to regulatory delays the research project was unable to get underway until July of 1998. At this time the raised bed was amended with the polymer treatments, and leaching began by mid-August. There were seven leachings with city of Saskatoon treated water, of approximately one inch per leach. Leaching was completed for the year on September 25. N and P fertilizer was added on October 5, sediment samples were taken October 20, to determine the success of the summers leaching, and seeding commenced with *Puccinellia distans, Agropyron smithii* and *trachycaulum,* and was completed by October 21. Results of the soil analysis indicated that there was a significant decrease in the level of salts contamination, however there was no significant treatment effect. There was evidence that the polymer had sequestered salt during the course of the leaching. There was also evidence of a 'locational effect', within the raised bed, which appeared to be the result of the water table depth within the slime tailings holding facility. This factor was confirmed during the summer of 1999 sediment sampling. Benchtop studies done during 1998-9 also confirmed that polymer treatments had little significant effect on leaching. It was confirmed that the polymer appeared to sequester the salts and gradually release them during the leaching process, whereas the control, with no polymer addition, was able to successfully leach salts as long as drainage was available.

Due to recontamination of the site during late 1998 and during the 1999 growing season, as a result of a substantial rise in the water table, cores were taken from cells containing *Puccinellia distans*. The other two grasses, *Agropyron smithii* and *trachycaulum*, had lost seed viability and were therefore excluded from the remainder of the experiment. The soil cores were put into a growth chamber and leached with 1.5 inches of distilled water per leach. The goal of this alteration in the research experiment was to determine if germination of the *Puccinellia* was possible under lower EC conditions, and if so, at what eluate and soil EC it would occur, and how much leaching water would be required to achieve this. After only 4 leachings germination occurred in two of the control cores which had visibly slower infiltration rates than most other cores, especially the cores containing polymer. Sediment containing hydrated polymer has a visibly looser soil structure and water infiltrates very quickly.

How did this growth chamber experiment differ from that of the greenhouse? Why the conflicting results between the greenhouse, growth chamber, and field experiments? One factor that was evident in both the greenhouse and the two growth chamber experiment results was very rapid water movement through many of the cores or pots. During the greenhouse experiment, a delay period near the beginning of the experiment, where no water was added, apparently caused substantial internal drying of the treatments and shrinkage. This enabled water to move down the sides of the control pots, instead of

through the sediment, whereas those pots which were amended with polymer, having an extra water store in the polymer, were delayed in their shrinkage depending on the level of polymer added. Any shrinkage which did occur within the polymer treatments appeared to allow water to pool around the polymer where it was soon soaked up and which thereby caused expansion of the sediment/polymer mix in the pot. It is hypothesized that the added water storage of the polymer prevented the same effect of shrinkage as what occurred in the control pots, and thereby promoted greater downward movement through the sediment itself, removing greater amounts of salt. If a barrier could have been placed down the sides of the pots, thereby preventing water from escaping down and out the sides of the pots, it is hypothesized that the same effect as what was seen in the growth chamber and benchtop experiments would have occurred.

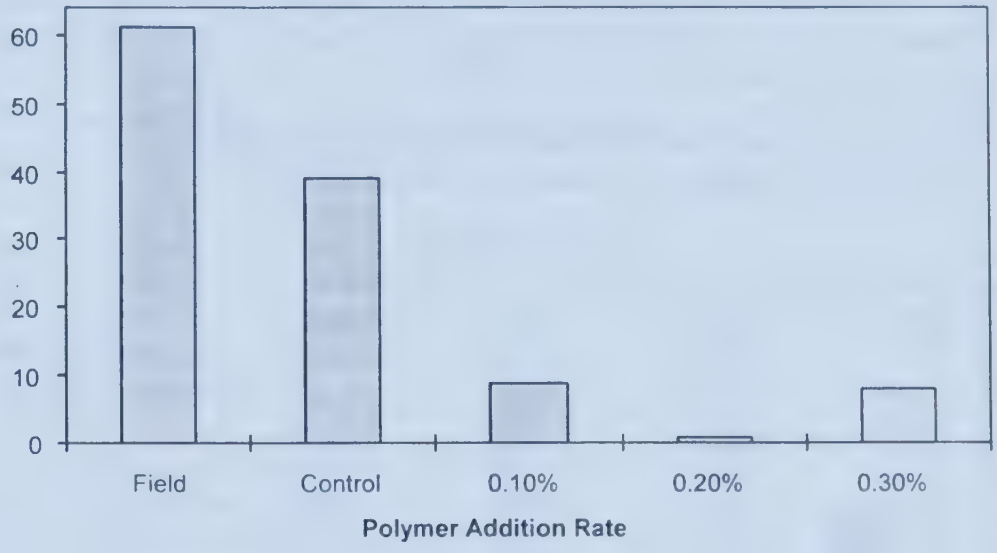

Figure 1.0 SAR Treatment Comparison, Using Saturated Pastes, of a Greenhouse Experiment on Potash Mine Slime Tailings

Figure 2.0 shows effective leaching in all treatments of the raised bed over time when comparing with the compacted walkway, contained in the raised bed, and with the perimeter, in the tailings, samplings. There appears to be a significant drop in EC values in all treatments when comparing the summer and fall 1998 samplings. The increase in EC noted in the summer 1999 samplings, caused by the rise in the tailings water table, appears to exert a greater effect in the polymer treatments. It is in these treatments that the rise in EC is more substantial, especially in the 0.3% polymer addition treatment.

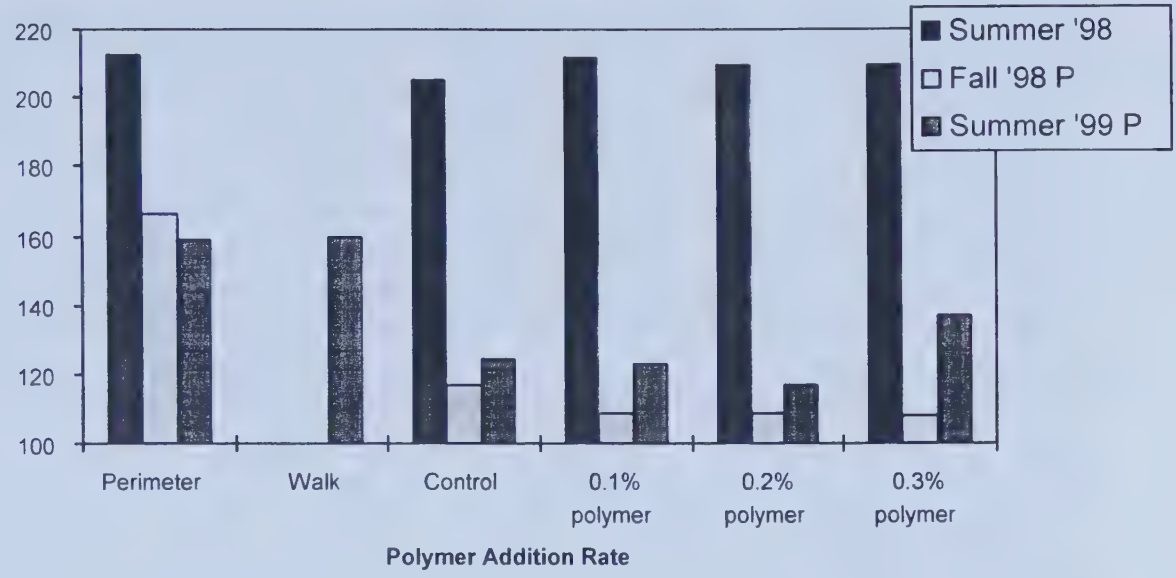

Figure 2.0 Comparison of Treatments Over Time Using Saturated Pastes of Potash Mine Slime Tailings

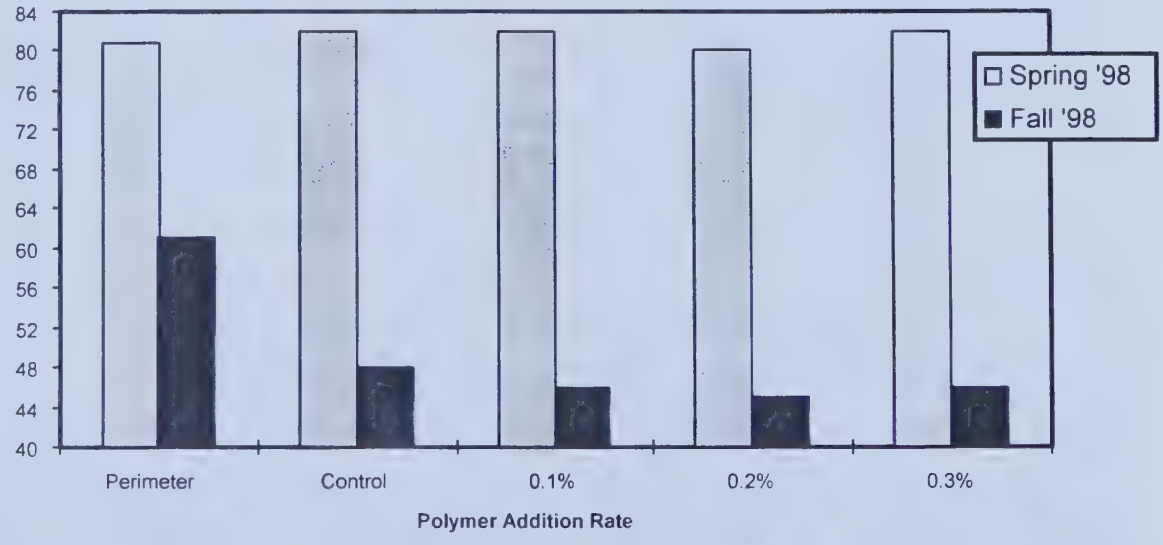

Figure 3.0 Comparison, Using Saturated Paste Analysis, of SAR Values for the Potash Mine Slime Tails Spring and Fall 1998 Samplings

SAR values in Figure 3.0 indicate, as do the EC values in Figure 2.0, effective sodium salt leaching between the summer and fall 1998 tailings samplings. The effective decline in SAR values lie between a 40 and 50 % decline in SAR values with only a couple months of leaching. This is extremely positive data indicating that these tailings could be effectively leached quite quickly assuming adequate drainage was provided.

3.0 Conclusions

In conclusion, it is the opinion of the author, that the potash mine slime tailings, located at Vanscoy, SK, could be successfully reclaimed with adequate drainage, i.e. a substantial lowering of the water table in the tailings holding facility, and sufficient leaching of salts out of the system, i.e. through irrigation with good quality water and removal of the leachate from the area. Although polymer does exert a positive effect regarding decreasing surface evaporation, providing a more stable surface, i.e. decrease in erosion, and providing a looser soil structure, its ability to sequester cations, which are released over time, reduces its effective use in leaching salts and reclaiming the potash mine slime tailings located at Vanscoy, SK. The polymer may be more effective in soils containing appreciably higher percentages of clay where compaction may be a greater threat to effective leaching, or in tailings where erosion may pose a threat to the protective dikes, i.e. polymer sprayed on the surface for surface stabilization. The soil textural qualities, i.e. silty clay (Pierzynski, et al. 1994), of the tailings from the Agrium site, permit effective leaching of the salts under adequate drainage conditions and polymer addition appears to delay this leaching process.

4.0 References

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Plant and Soil, 43, 355-369

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