NALCO

RECENT DEVELOPMENTS IN BEET TRANSPORT WATER MANAGEMENT

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Personal chemistry makes the difference.

INTRODUCTION

If you were to ask the Operations Manager of a typical Northern United States sugar beet processing factory what his biggest non-process related problem was, chances are excellent that he would tell you "ODORS!". These odors, which range from musty smells to hazardous gases, are a nuisance to the community and to the factory personnel. The problem is severe enough that by our best estimate the US beet-sugar processing industry spends at least $4,500,000.00 annually on odor masking agents, pH control reagents, foam control, bioaugmentation, settling aids, and other "quick fix" methods to minimize the odor problem. This significant investment rarely, if ever, produces a favorable return, and results are typically based on anecdotal observations rather than quantifiable data. Nalco, utilizing an extensive experience in raw water and waste water treatment techniques, has enabled clients in other industries to reuse and recycle wastewater successfully. This has helped our clients eliminate the root cause of fresh water supply and wastewater management problems. Recently, Nalco has used some of these resources to assist some of our sugar beet processing clients in Minnesota and North Dakota to identify and eliminate the "Root Cause" of the sugar beet factory odor problem. This paper discusses the basic concepts and results of work in progress.

BACKGROUND

Most of the odor producing compounds in the factory wastewater treatment loop result from the uncontrolled anaerobic biological decomposition of the organic materials removed from the beet transport water system. The "mud" from the flume water clarifier is typically impounded in an open lagoon system. Here the solids are allowed to settle out and the supernate water is removed to replenish the beet transport (flume) water, or is sent to the factory wastewater treatment system. The volume of "mud" varies quite widely from factory to factory based on the harvest soil condition of the incoming beets, the amount of lime added to control transport water pH, the operational practices of the flume water clarifier, and any mechanical dewatering/thickening capabilities.

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The flume water system is designed to transport the beets from post-harvest storage locations into the factory while simultaneously removing field dirt, rocks, and other trash that might adversely affect slicing and diffusion. Flume water also may receive small waste streams from the factory such as furnace ash sluice water, excess condensates, and cooling waters. The most common method of flume water treatment is to maintain the pH in the range of 11.0 - 12.0 using lime. It is well documented that maintaining this high pH retards acid forming bacterial activity. The lime addition also promotes precipitation of magnesium hydroxide if the pH is above 10.5 ($Ca(OH)_2 + MgCO_3 = Mg(OH)_2 + CaCO_3$) and calcium carbonate ($Ca(OH)_2 + Ca(HCO_3)_2 = 2CaCO3 + H_2O$) if the pH is below 10.0. Operators generally observe that a cleaner flume water clarifier effluent can result from the co-precipitation and weighting action of the additional suspended solids contributed by the lime. Some factories have chosen not to pH adjust their flume water systems accepting the corrosion damage, H2S gas, and sugar loss of the acid producing bacteria in the flume water as a normal cost of operation.

Since 1986 Nalco has been involved with our clients in Minnesota and North Dakota to help reduce the volume of "mud" coming out of the mechanical flume water clarifiers. We took the normal route for a specialty chemical company and used organic polymers to aid in thickening of the mud. Initial results were generally encouraging with volume reductions of 40-60%, but performance was not consistent. Statistical analyses showed us that their were "special" causes of variation that needed to be eliminated before the mud volume reduction process could be considered statistically capable.

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Bench-scale studies showed a significant correlation between "mud" dewaterability and pH. In general, "mud" pH above 11.5 or below 8.0 did not settle or dewater well.(Figures 1 & 2) These findings are consistent with our knowledge of waste sludge from both cold-lime-softening municipal water treatment plants and pulp and paper mill green liquor clarifiers. In municipal water treatment lime is added to both clarify and reduce the level of calcium and magnesium in the drinking water. This makes it "softer" and easier to wash and clean with. The basic process is similar to the juice purification process in the sugar beet factory. The water-holding (hydrous), voluminous nature of the magnesium hydroxide precipitates in this high pH sludge makes it very difficult to dewater. When the pH falls to below 10.0 the primary precipitate is calcium carbonate which is about 1/8th the size of magnesium hydroxide and traps less water. One other operational concern with lime addition is that when the pH drops below 11.0 it is typically very difficult to get the pH back up due to the increased acid-forming bioactivity in the flume-water. As the pH falls, the factory may also experience severe scale formation on screens, in piping, and in circulating pumps. This increases the maintenance costs and potentially can slow slice rates.

The typical root cause for flume water with a low pH is acid-forming bacteria actively decomposing high levels of soluble organics in the flume water from degraded or damaged beets. **The acid-forming bacteria generate gases as a waste product that accelerate the foaming tendency of the flume water and further hinder the settling of the "mud" and soils in the clarifier.** The biological degradation of the soluble organics in the flume also may lead to the formation of natural organic anionic charge reinforcing dispersant compounds. **These compounds may hinder the flocculation and settleability of the nearly colloidal fine soil particles.** In the early years of water treatment chemical additives natural dispersant compounds found in today's typical beet flumes such as dextran, cellulose, lignin ,and pectin were used to prevent mineral scale and silt fouling. Operating at low pH's changes the stability of the flume water to a corrosive nature. This leads to corrosion of metal and concrete components of the beet transport system. Increased requirements to slice more beets faster make the significant maintenance time and expense to repair the flume even less attractive. **Excessive fermentation gas production may also increase the exposure of operating personnel to health and explosion risks from hydrogen sulfide gas.**

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The recent trend toward longer processing campaigns and virtually year-round molasses desugarization or other by-product operations results in new challenges to wastewater processing. Pond/lagoon systems that could normally be processed and emptied during the intercampaign period are now filling up. Irrigation practices are being closely scrutinized by regulatory agencies. Land for more ponds or irrigation is either not available or is too high priced. The relative strength of the wastewater organic load has increased pushing the factory-specific wastewater treatment systems to their limits leaving no room for slowdowns or "upset" recovery. Local regulatory agencies are demanding aggressive action to abate odor complaints and meet ever tighter discharge water quality requirements. The past procedure of adding fresh potable quality water to a "sick" flume is typically not feasible due to increased cost or lack of availability coupled with the lack of pond space to store the added gallons. The root cause focus keeps coming back to reuse and recycle of flume water.

THE TROUBLE WITH LIME

Acid production is a natural, continuous process in stored sugar beet processing. The rate and volume of acid produced is a factor of stored beet conditions and flume-water acid-forming bacteria activity. To maintain an acceptable flume water pH these acids must be neutralized by bicarbonate, carbonate, or hydroxide alkalinity. **The practice of adding lime to control the pH of recycled beet transport water is actually counter-productive!** It reduces the alkalinity in the water as it precipitates the calcium and magnesium associated with carbonate and hydroxide alkalinity species respectively. Removal of alkalinity reduces the "buffering" capability of the water making it much more susceptible to low pH excursions. As you can see from the following equations in the typical beet transport system, each pound of lime you add to the flume water reduces the bicarbonate alkalinity by 2 pounds by forming calcium carbonate from the carbon dioxide and bicarbonate alkalinity (Equation 1). Taking the flume-water pH up to 11.0+ means you will also precipitate magnesium hydroxide which also results in a one for one alkalinity reduction (Equation 2). The alkalinity remaining at a pH above 11.0 is exclusively in the hydroxide form which does not exist below a pH of 10.2 explaining the difficulty encountered maintaining the pH between 5 and 10 using only lime.

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SUMMARY

It appears to be technically and economically feasible to reduce or eliminate the use of lime in the treatment of beet transport water. The expected benefits of this approach are:

1. Reduced sludge volume in mud ponds.- Less solid waste to handle and dispose of. Room to expand to accommodate longer campaigns and intercampaign bi-product runs.

2. Improved dewaterability of sludge in mud ponds.- Recover recycle water faster. Reduce the mud pond area. Enable faster turn around on the ponds.

3. Reduced odor complaints.- Organics that cause odors as they degrade can be leached out of the mud and treated in a controlled manner rather than waiting for nature to take its course during the warm weather months.

4. Improved stability of the flume-water.- Reduced potential for corrosion and/or scale formation that can cost you production or maintenance dollars.

5. Ability to reuse wastewater in the flume.- Reduced freshwater consumption. High dissolved solids in recycle water will also equalize the osmotic pressure between the flume water and the beets reducing the tendency of sugar to diffuse out of the flumed beets. Reduced inventory of wastewater to treat and discharge, irrigate or impound.

6. Reduce or eliminate flume-water foaming - Reduced antifoam consumption. Improved settling in flume-water clarifier

Nalco would like to thank the operations and management personnel of American Crystal Sugar factories in Drayton, ND ; East Grand Forks, MN ; Crookston, MN ; Hillsboro, ND ; and Moorhead, MN for their assistance in generating the data for this paper. These professionals have demonstrated the initiative to achieve continuous improvement in all aspects of beet sugar processing!

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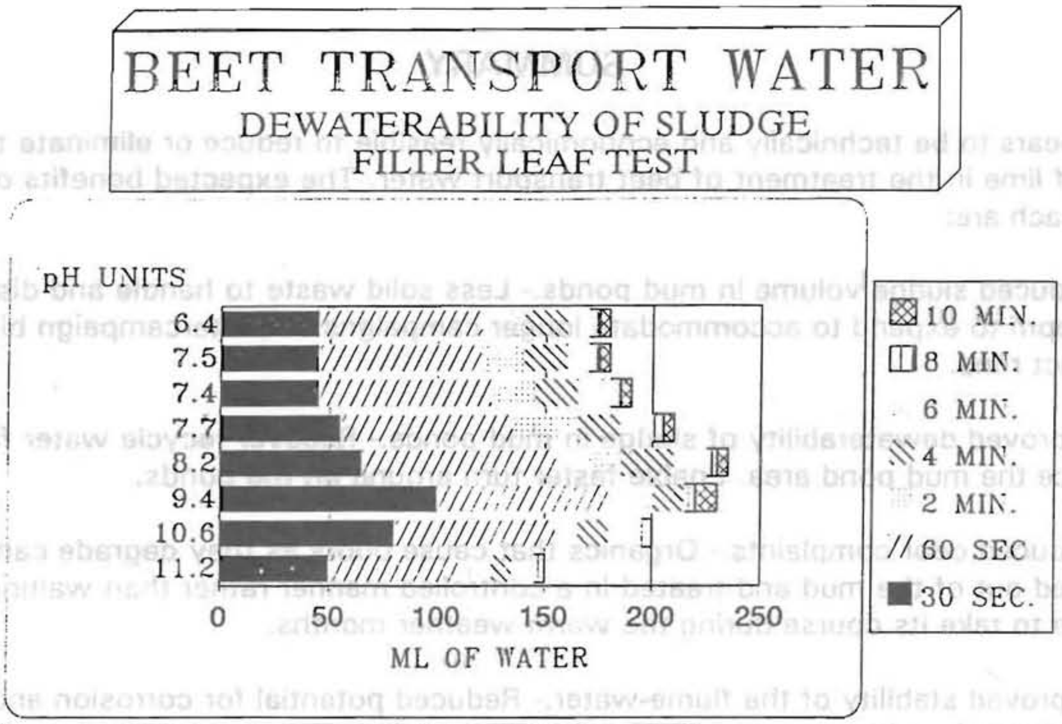
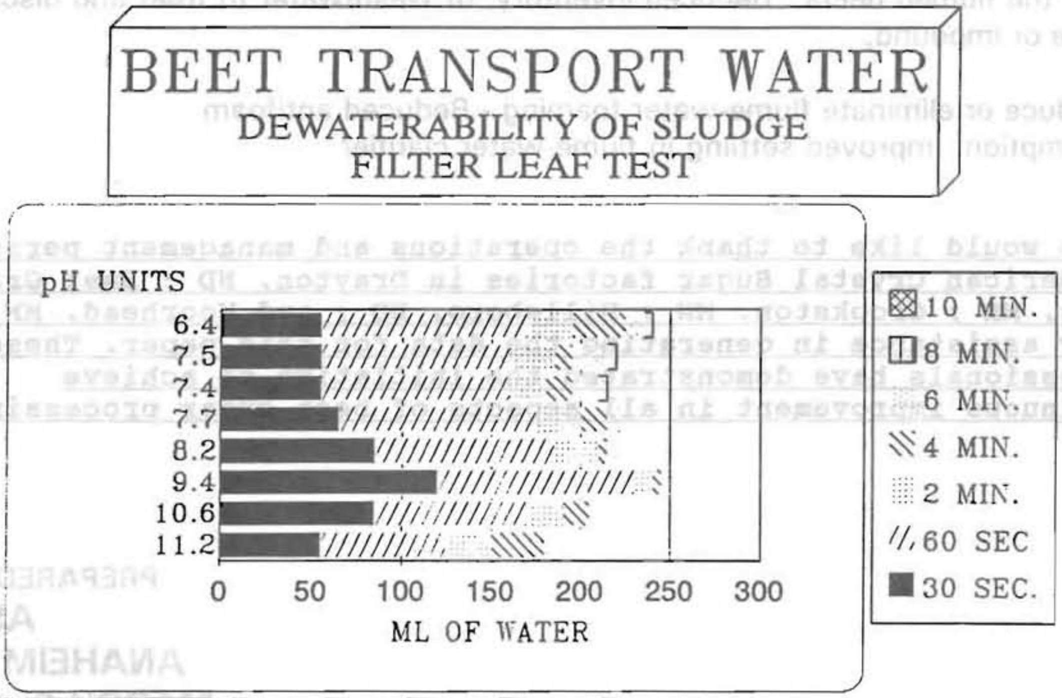


250 ML SAMPLE OF CLARIFIER UNDERFLOW

FIGURE 1



250 ML SAMPLE OF CLARIFIER UNDERFLOW
5 LBS POLYMER/DRY TON SLUDGE

FIGURE 2

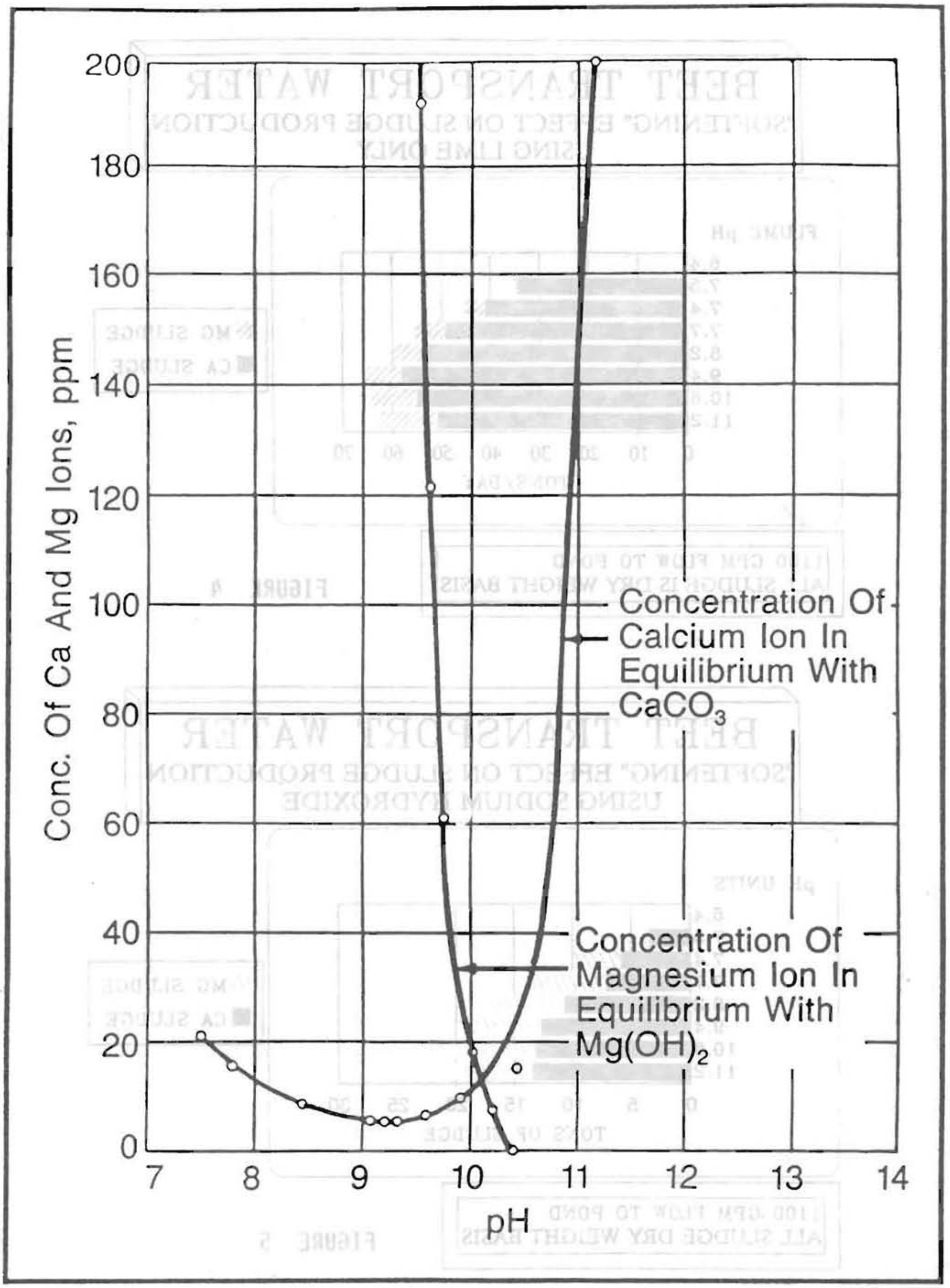
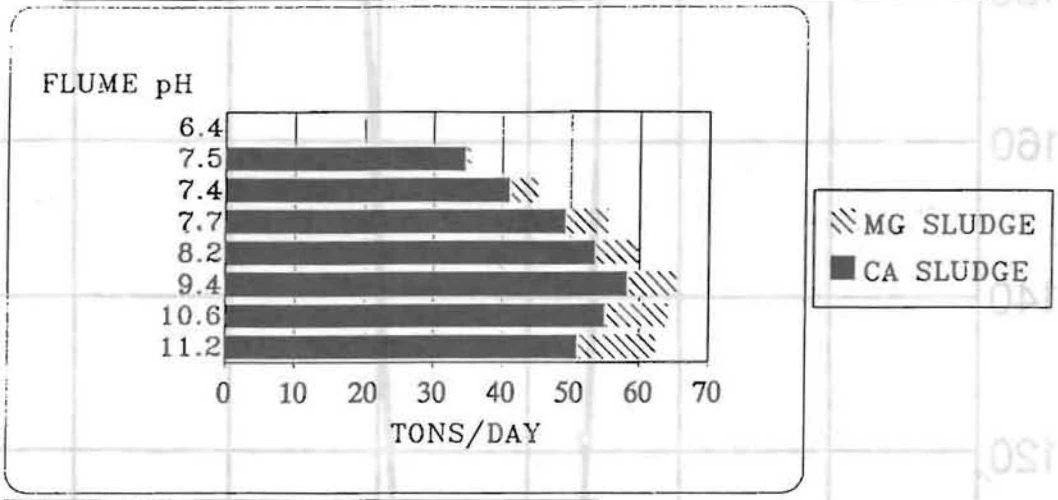


***Figure 3** — Equilibrium concentration of calcium and magnesium ions plotted against pH*

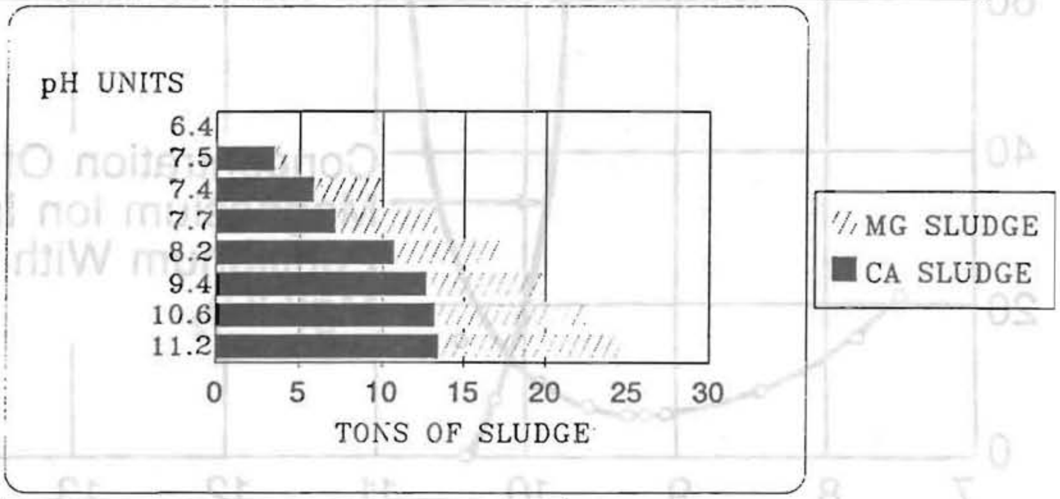
BEET TRANSPORT WATER
"SOFTENING" EFFECT ON SLUDGE PRODUCTION
USING LIME ONLY



1100 GPM FLOW TO POND
ALL SLUDGE IS DRY WEIGHT BASIS

FIGURE 4

BEET TRANSPORT WATER
"SOFTENING" EFFECT ON SLUDGE PRODUCTION
USING SODIUM HYDROXIDE



1100 GPM FLOW TO POND
ALL SLUDGE DRY WEIGHT BASIS

FIGURE 5

BEET TRANSPORT WATER
"SOFTENING" EFFECT ON FLUME pH USING LIME ONLY

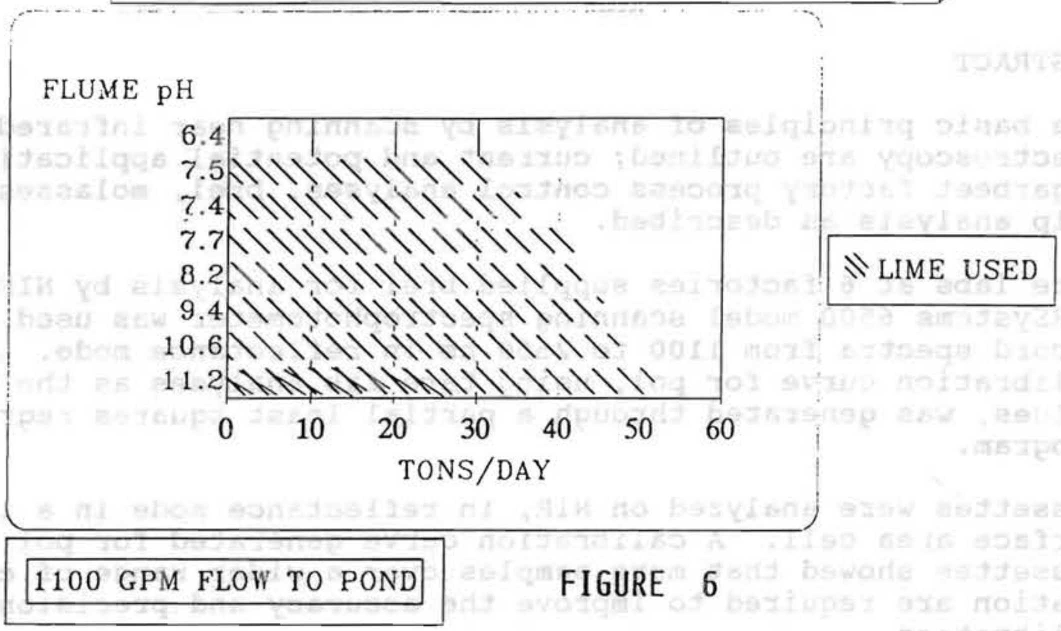


FIGURE 6

BEET TRANSPORT WATER
"SOFTENING" EFFECT ON pH SODIUM HYDROXIDE DAILY USAGE

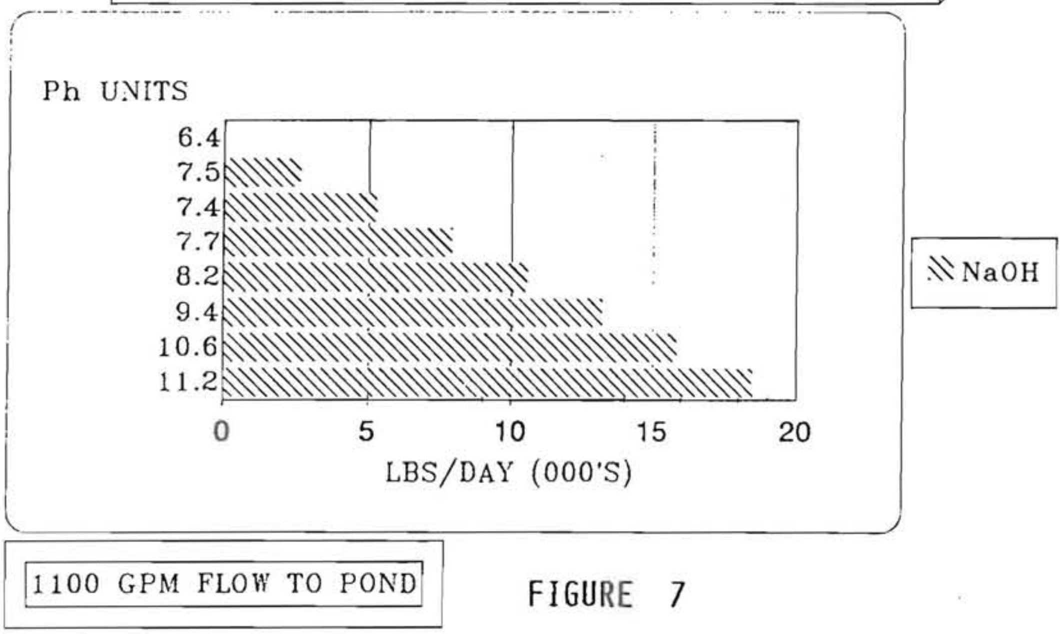


FIGURE 7