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Electrokinetic Treatment of Sludge

Matthew G. Kwiatkowski
Western Michigan University

ELECTROKINETIC TREATMENT OF SLUDGE

BY

Matthew G. Kwiatkowski

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ABSTRACT

Disposal of sludge has become a major issue in the pulp and paper industry because of the decreased space in landfills and the possibility of pollution from the sludge. By increasing the amount of solids in the sludge (dewatering), the sludge could be disposed of using less land or by incineration, composting, or other method. The dewatered sludge is easier to handle also because of its decreased volume. The method of dewatering which was used for the experiment was by electrokinetics. Electrokinetics is the technology of separating solids and liquids from suspensions of finely divided solids or colloidal particles using an electrical potential.

Using four different power levels, a final solids level of 5.9% was reached and a decreased volume of almost 50%. This data showed that electrokinetics does have the potential to greatly reduce the volume of material which needs to be disposed of. It may also be able to increase the solids level to a higher level with further modifications.

TABLE OF CONTENTS

TABLE OF FIGURES

INTRODUCTION

Over the last ten years, the pulp and paper industry has made great strides in reducing its biochemical oxygen demand and total suspended solids. Due to this high degree of treatment, over 2.1 million ton/year of low-solids sludges is produced by the U.S. pulp and paper industry (1). The need for better methods of solid waste disposal is well known. Currently, landfilling solid waste is the predominant way used for disposal. Sludge disposal follows the same path as the solid waste stream. It is mostly landfilled. If the sludge is disposed of improperly it may be a source of pollution, a disaster hazard when placed in dumps and a real physical problem just to stow the tremendous volume of material. Sludges are being studied for use as a raw material, such as in composting, but it is difficult to imagine sufficient consumption to reduce the need for disposal. Therefore, safer and more efficient methods of sludge stabilization are required.

By increasing the amount of solids in the sludge (dewatering), the sludge can be disposed of using less land or through other processes, such as incineration, composting, or burning for energy recovery. Dewatering is presently done by a number of methods, V-type presses, screw presses, or belt filter presses to name a few. One method which has been used for treatment of mining tailings, slimes, and other "lagooned" material, is electrokinetics. Electrokinetics is the technology of separating solids and liquids from suspensions of finely divided solids or colloidal particles. It includes electrophoresis, electrodialysis, and electroosmosis. Basically, to practice material dewatering by electrokinetics, a D.C. potential is applied to electrodes installed at selected spacings in the material to be dewatered. The electrical potential causes positive ions in the water to move away from the anode to the cathode carrying the water to the cathode. Once deposited at the cathode, these ions release their water which can be collected (2).

BACKGROUND

There are a number of applications to include the separation and the drying of products from a process stream. The Bureau of Mines (3) and Dorr-Oliver have developed electrical systems for dewatering clays from aqueous slurries. Dorr-Oliver has been awarded three patents for their systems. Electro-settlers have been used to settle effluent solids. These systems are somewhat of a technology which bridges the gap between continuous equipment for process-stream treatment and permanently installed equipment for large pond or lagoon treatment. Batch methods for dewatering tailings, slimes, and other "lagooned" materials have been developed by the Bereau of Mines. In a study to determine the feasibility of recovering coal from a tailings pond, the Bureau found that they could raise the solids content of the tailings up to about 80% from about 30% (4).

Some workers have tried to use this technology as a means to densify and dewater some very difficult to handle material. Research has been done on dewatering, settling, or thickening phosphate limes by electrical methods (5) and in England, a continuous unit to process municipal sewage has been designed. Dreged material has also been dewatered using this method although it is not the most effective method. These programs showed that electrokinetics may not be the best way to dewater some of these materials, but they did show that materials which did not give up water easily might be dried under the appropriate conditions using this technology.

The main objective of my Senior Engineering Problem was to design a batch type of electrokinetic treatment system which would dewater a sample of sludge. The amount of water which is removed and the amount of energy needed to accomplish the dewatering will be monitored to determine the efficeincy of the system.

EXPERIMENTAL DESIGN

A tank 2 ft. high, 2 ft. in depth, and 14 in. in width was used to conduct the experiments. The tank was made out of a wooden crate lined with a 6 mil. plastic. The electrodes floated on the surface of the sludge, one cathode and one anode. Both electrodes will be placed 6 in. from either end and 7 in. from either side leaving them along the center line of the tank, 1 ft. from each other. The cathode was 1 ft. long made out of 3/4 in. I.D. iron pipe which was slotted parallel to the length to allow the water to pass inside the cathode for collection. the water was removed from the cathode by a glass tube connected to plastic tubing. The tubing was connected to a pump which discharged into a 5 gal. bucket for water collection. A piece of felt was wrapped around the cathode to act as a filter to keep any solids from escaping the tank. The anode was constructed out of a steel dowel, 1 ft. in length and 3/8 in. in diameter.
The power source used was a straight D.C. current which was adjusted each time the amount of water removed was measured. The sludge was collected from James River Paperboard Group on Paterson St., in Kalamazoo, MI. The sludge was taken immediately from the collection point to the tank before each run so the sludge was probably not

exactly identical but since the mill which I got the sludge from is a recycle mill, and not a lot of chemicals are used in the process, the sludge should not have varied too greatly.

Initially, the sludge was tested for solids and ash content before the start of each run. After the start of each run the amount of time to dewater the sludge was monitored. The run was stopped whenever the flow of water being removed was zero. The voltage applied to the electrodes and the current flowing through the sludge will be collected at intervals of a few hours at the start of each run and then every 6-7 hrs. near the end of each run.

The amount of water removed and the power consumption was calculated from the data which was collected. The moisture content of the sludge at the end of each run was taken only as an overall tank moisture. Initially, a moisture profile and the moisture at the electrodes was going to be taken but a sampling tube was not found that adequately performed the task.

RESULTS

Five different runs were accomplished using electrokinetics, each one was run at a different power level. As a basis, no power was applied to the electrodes and the pump was run to see how much dewatering was due only to water being drawn to the cathode by the action of the pump. The following four runs used increasing current amounts of 50ma, 100ma, 125ma, and 250ma. The current was kept as constant as possible throughout the runs.

Table 1 shows the level of solids which was reached at the end of each run and the beginning solids level.

Table 2 shows the amount of water removed as a percentage of the total volume at the start of each run.

TABLE 1.

% SOLIDS OF THE SLUDGE

	BEFORE	AFTER
0 ma	1.8%	2.3%
50ma	2.3%	4.4%
100ma	1.2%	3.3%
125ma	2.2%	3.4%
250ma	3.0%	5.9%

TABLE 2.

% WATER REMOVED

0ma	23.8%
50ma	44.6%
100ma	46.2%
125ma	36.7%
250ma	49.6%

Figure 1 shows the amount of water removed versus time.

Figure 2 shows the amount of energy used versus time.

CONCLUSIONS

The data which was collected did not really show what was expected. Figure 3 shows what was expected. The amount of water removed should have increased more rapidly then what actually happened, except in the case of the run which used 50ma. The 50ma run acted as expected and this was probably due to the fact that it was the first run which used a D.C. potential. Because of the greater movement of material during this run the filter sock, which was not replaced at all during the entire experiment, probably got plugged and did not allow the water to move as easily through it during the later runs. Also, the energy consumption jumped rapidly up during the 250ma run. This was probably due to the corrosion of the cathode which was finally severe enough to cause the power to increase significantly. This was later confirmed after the experiment when the cathode was examined and severe corrosion was noticed.

Although the experiment did not follow the expected path, it did show that dewatering is possible using this method. The level of solids never reached a level where the material could be burned efficiently but the volume of material decreased by up to about 50% during the last run of 250ma. Also though, 46.2% volume reduction was achieved using 100ma so the amount of power did not significantly affect the volume of water removed. This means that it could possibly serve as a means of volume reduction and not a means to largely increase solids.

FIGURE 1.

WATER REMOVED VERSUS TIME

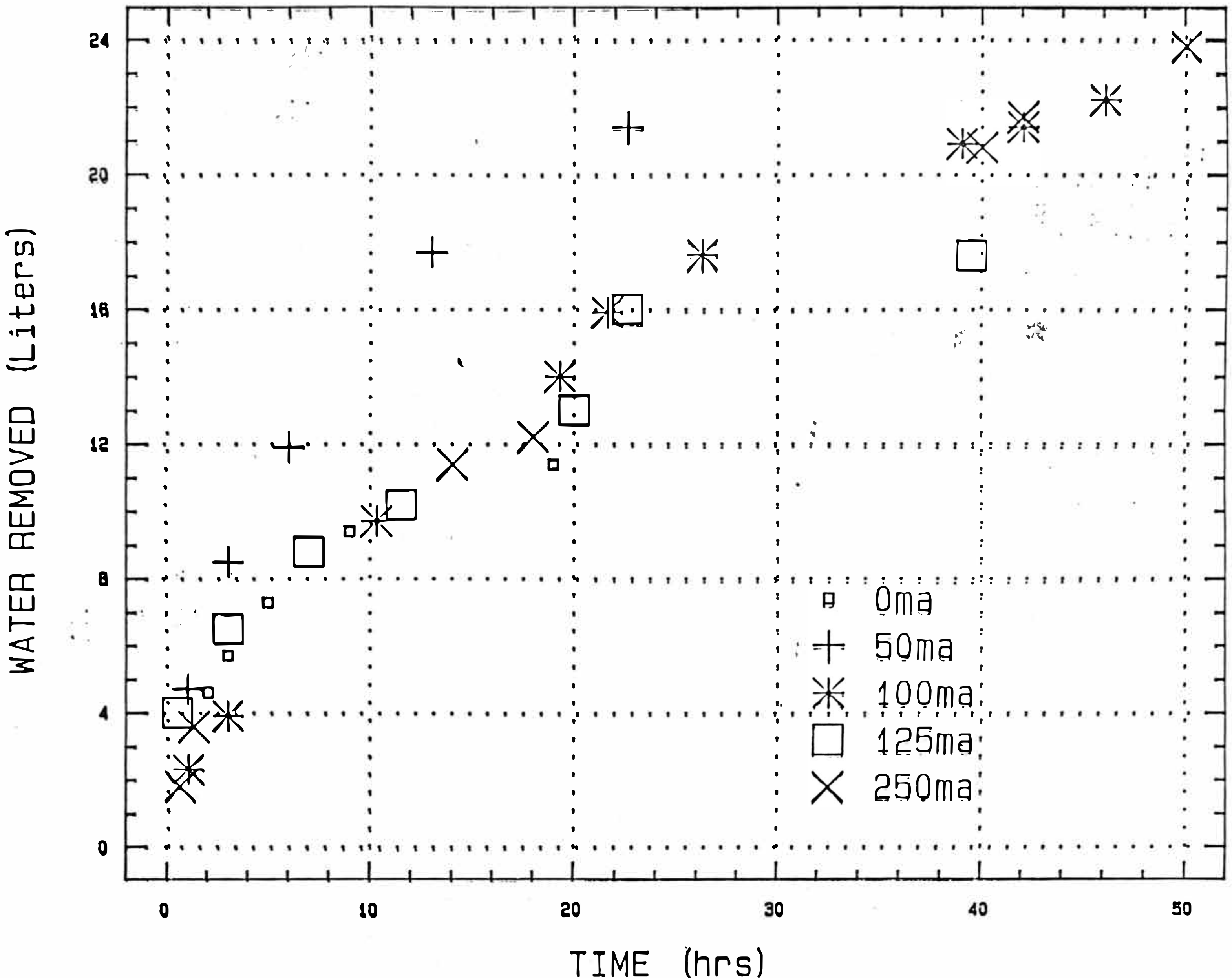
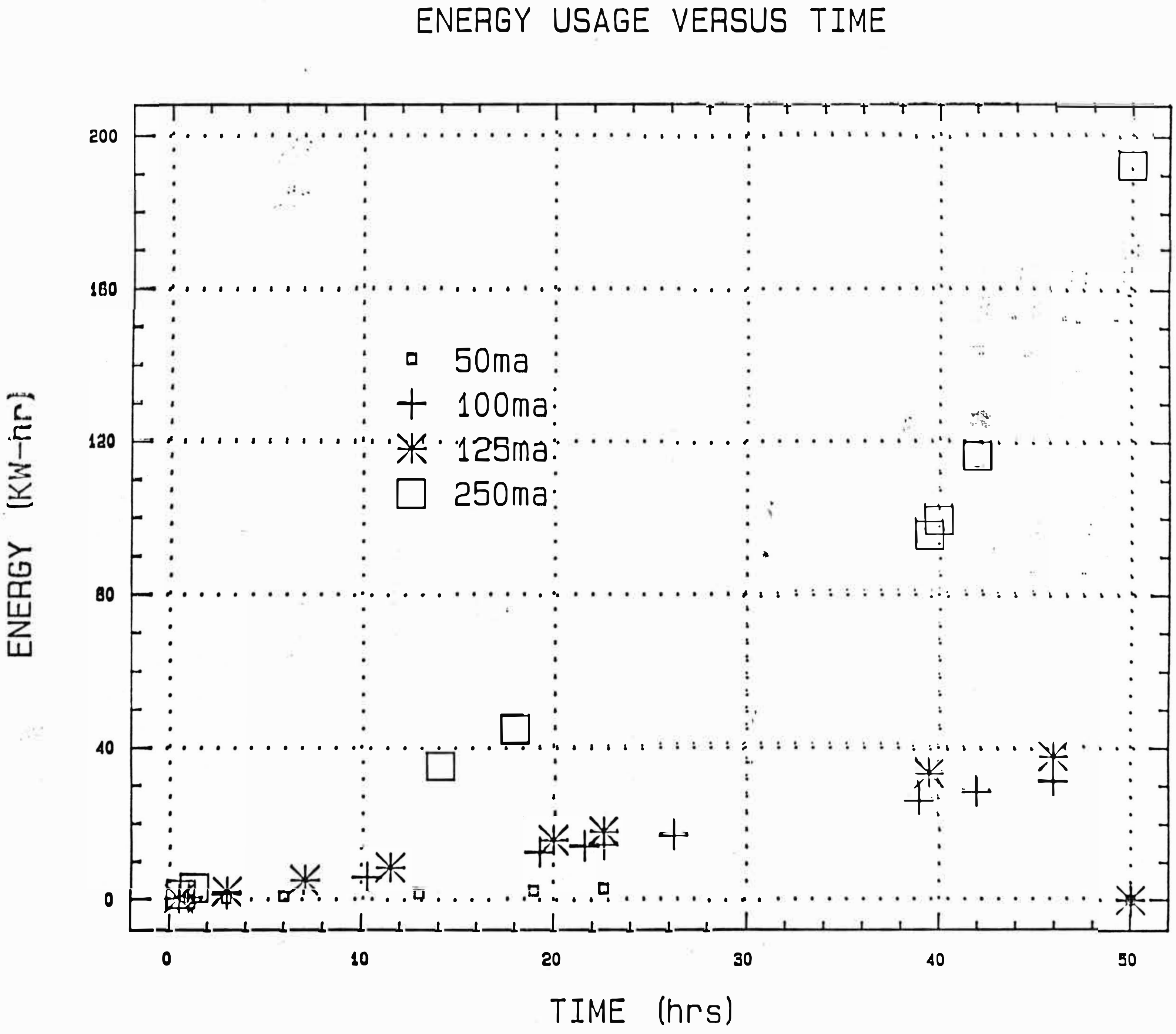
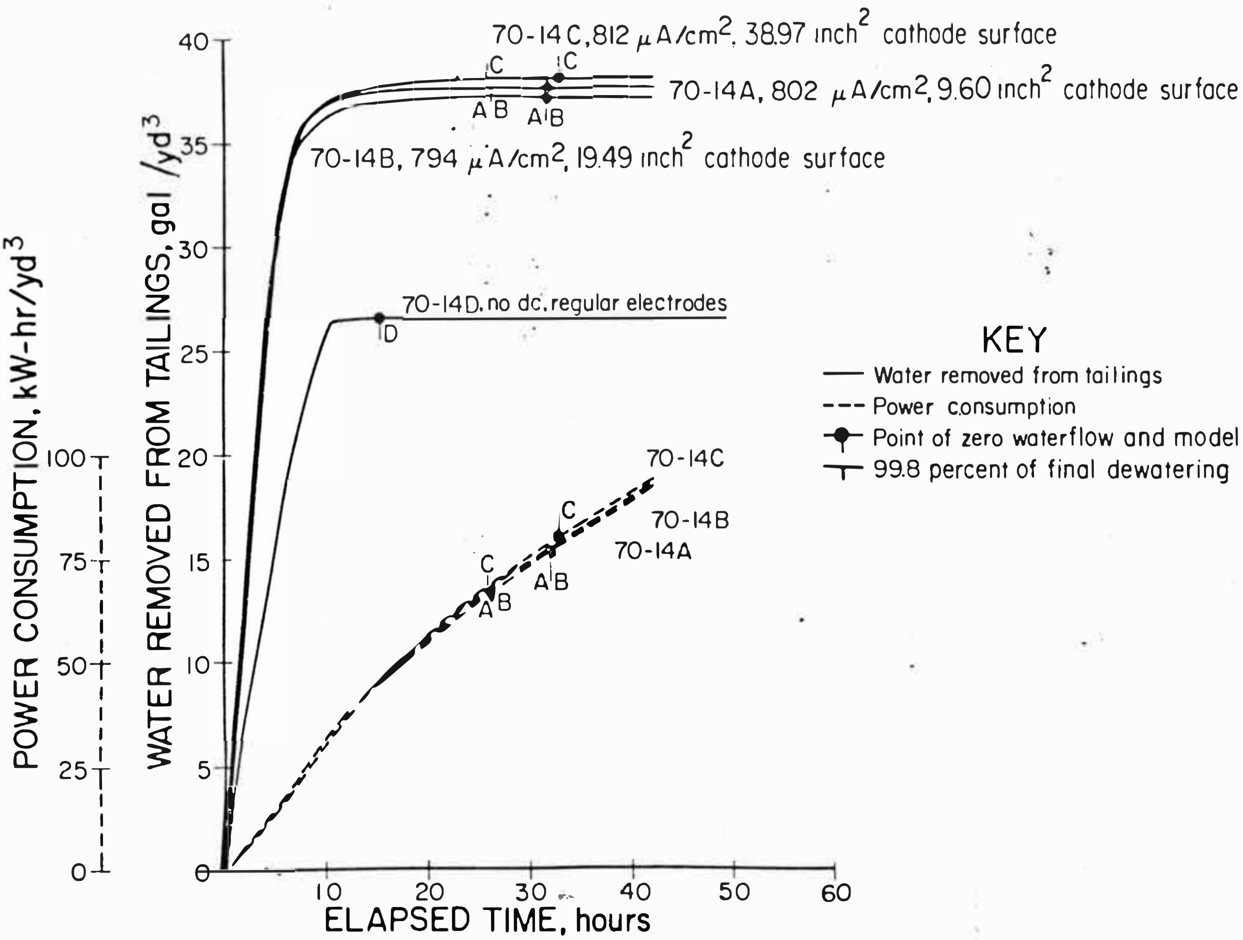


FIGURE 2.


ENERGY USAGE VERSUS TIME
ENERGY (KW-hr)
TIME (hrs)
50ma
100ma
125ma
250ma
200
160
120
80
40
0
0
10
20
30
40
50

(8)

FIGURE 3.
EXPECTED



RECOMMENDATIONS

The potential is there for electrokinetics to be a valuable method of dewatering sludge. I feel that the testing should be done again with at least two tanks running at the same time to take away the possibility of any variances in the sludge. If variances due occur, it would be pointed out by the fact that two runs following the same pattern while two other runs following a different pattern. Also, there are many variations which could be used in the design of the system. A pulsed D.C. current could be used thinking that the pulse will create more dewatering. Mechanical vibration could be used to free more water for movement or the current could be reversed periodically to help reduce resistance due to gas formation on the electrodes. One other way which may increase the amount of dewatering is to use different shapes and sizes of electrodes which would create different electrical fields in the sludge.

REFERENCES

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APPENDIX A. RAW DATA

		WATER REMOVED			
HOURS	0amps	50ma	100ma	125ma	250ma
0.5				4	
0.6					1.8
1		4.7	2.3		
1.3					3.6
2	4.6				
3	5.7	8.5	3.9	6.5	
5	7.3				
6		11.9			
7				8.8	
9	9.4				
10.3			9.7		
11.5				10.2	
13		17.7			
14					11.4
18					12.2
19	11.4				
19.3			14		
20				13	
21.6			15.9		
22.6				16	
22.6		21.4			
26.25			17.6		
39			20.9		
39.5				17.6	
40					20.8
42			21.4		21.7
46			22.2		
50					23.8

APPENDIX A (CONT.)

HOURS	VOLTAGE APPLIED 50ma	100ma	125ma	250ma
0.5			5.5	
0.6				9.5
1	2.4	4.9		
1.3				9.5
2				
3	2.5	4.8	5.7	
5				
6	2.7			
7			5.9	
9				
10.3		6.4		
11.5			6.1	
13	2.9			
14				10
18				10
19	2.4			
19.3		7.2		
20			6.7	
21.6		6.8		
22.6			7.1	
22.6	2.9	4.7		
26.25		6.9		
39		7.3		
39.5			7.3	9.5
40				31.5
42		7.4		33.5
46		6.6	5	
50				38

APPENDIX A (CONT.)

HOURS	ENERGY USED 50ma	100ma	125ma	250ma
0.5			0.34	
0.6				1.43
1	0.12	0.49		
1.3				3.09
2				
3	0.37	1.45	2.12	
5				
6	0.77			
7			5.07	
9				
10.3		6.12		
11.5			8.50	
13	1.78			
14				34.84
18				44.84
19	2.50			
19.3		12.60		
20			15.62	
21.6		14.16		
22.6			17.93	
22.6	3.02	14.63		
26.25		17.18		
39		26.49		
39.5			33.44	95.90
40				99.84
42		28.71		116.64
46		31.35	37.82	
50				192.64