United States
Environmental Protection
Agency

Municipal Environmental Research
Laboratory
Cincinnati OH 45268

EPA-600/2-80-112
August 1980

Research and Development

EPA

Monitoring Septage Addition to Wastewater Treatment Plants

Volume II: Vacuum Filtration of Septage

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MONITORING SEPTAGE ADDITION TO WASTEWATER TREATMENT PLANTS

Volume II. Vacuum Filtration of Septage

by

Charles R. Ott
Burton A. Segall
University of Lowell
Lowell, Massachusetts 01854

Grant No. R805406010

Project Officer

Steven W. Hathaway
Wastewater Research Division
Municipal Environmental Research Laboratory
Cincinnati, Ohio 45268

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

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FOREWORD

The U.S. Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies and for minimizing the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report assesses the feasibility of dewatering septic tank wastes (septage) with conventional vacuum filters. A method of treating septage in combination with thickened waste activated sludge is demonstrated for adaptation at municipal wastewater treatment plants.

Francis T. Mayo
Director
Municipal Environmental Research
Laboratory

ABSTRACT

The study examined the feasibility of using conventional vacuum filtration to dewater conditioned septage sludge, by itself and in combination with thickened waste activated sludge. The septage was conditioned with aluminum sulfate, ferric chloride and sulfuric acid, each used independently. Laboratory experiments were conducted with a filter leaf apparatus that simulates a coil spring vacuum filter. The Capillary Suction Test, CST, was used to estimate filterability. Field studies, utilizing a full-scale vacuum filter and large quantities of septage, were conducted at the Medfield, Massachusetts, wastewater treatment plant.

The studies showed that vacuum filtration of a combined mixture of thickened waste activated sludge and septage conditioned with either alum, ferric chloride or acid is feasible. Excellent cake yields and filtrate quality were obtained.

The cost of treating septage in the solids handling train at Medfield was less than the cost of adding septage to the liquid stream at the plant inlet.

This report was submitted in fulfillment of Grant No. R805406010 by the University of Lowell under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period January 1978 to December 1979, and work was completed as of March 1980.

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LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

cm	--centimeter
COD	--chemical oxygen demand
CST	--capillary suction time
cu ft	--cubic feet
cu m	--cubic meter
gal	--gallon
hr	--hour
kg	--kilogram
kw-h	--kilowatt hour
ℓ	--liter
lbs	--pounds
mgd	--million gallons per day
mg/l	--milligrams per liter
ml	--milliliter
sec	--second
sq ft	--square feet
sq m	--square meter

SYMBOLS

Al(III)	--trivalent aluminum ion
$CaCO_3$	--calcium carbonate
Cd	--cadmium
Cr	--chromium
Cu	--copper
Fe(III)	--trivalent iron ion
H_2SO_4	--sulfuric acid
Ni	--nickel
P	--phosphorus
Pb	--lead
s	--standard deviation
SS	--suspended solids
TS	--total solids
TVS	--total volatile solids
TWAS	--thickened waste activated sludge
$\bar{x}$	--mean
Zn	--zinc

ACKNOWLEDGMENTS

The authors gratefully acknowledge the contributions made by their graduate research assistants, Diane Robinson and Edward Znoj. The accomplishments of the research were in large measure the results of their commitment to the laboratory and field projects.

The authors also acknowledge the cooperation and assistance given by the Medfield treatment plant staff, Plant Supervisor Kenneth Feeney, Peter Iafolla and Robert LaPlante. Mr. Feeney facilitated scheduling research activities with plant operation, provided equipment for material handling and septage transfer, and managed septage deliveries.

Appreciation is expressed to the Town of Medfield for permitting the use of its excellent facilities for research.

SECTION I

INTRODUCTION

TREATMENT OBJECTIVES:

Liquid and solids separation is a principal objective in the treatment of municipal wastewaters. At conventional activated sludge treatment facilities separation occurs both in primary sedimentation basins and following secondary biological conversion of dissolved organics to organisms. At primary plants only the former process is employed; at extended aeration plants only the latter. Septage can be introduced into the liquid waste stream at a treatment plant where it settles well in primary basins and is oxidized in aeration processes. However, oxidizing septage organics is costly and the solids concentration in septage is often on a par with the concentration of solids in streams generated in primary and secondary processes[1].

Septage introduction directly into the sludge processing train at municipal wastewater treatment plants is not generally practiced and the efficacy of treating septage with only sludge processing facilities has not been adequately studied.

Adding septage directly to the sludge processing train could reduce treatment costs at plants and would reduce the organic loading on conventional aerobic treatment processes. The technology is appropriate for proposed treatment plants and for existing plants where excess vacuum filtration capacity is available.

THE SCOPE OF RESEARCH

The purpose of this research was to determine the feasibility of dewatering chemically conditioned septage. The dewatering process utilized was a conventional coil spring vacuum filter. Septage was treated and vacuum filtered alone and in combination with thickened waste activated sludge, TWAS. Chemical conditioners used independently for the study were aluminum sulfate (alum), ferric chloride and sulfuric acid.

The laboratory phase of the study was conducted at the University of Lowell, where ten septage samples were chemically treated over a range of chemical dosages. Settled sludges were dewatered on a filter leaf apparatus at various form and drying time intervals and vacuum pressures. Cake yields and solids contents were determined; filtrates and supernatants were analyzed.

The laboratory tests were followed by full scale tests at the Medfield, Massachusetts Wastewater Treatment Plant. Selection of chemical treatments and dosages for the field tests were based upon the laboratory work. Ten full-scale field tests were conducted at Medfield, each utilizing about 45.4 cu m (12,000 gal) of septage. Septage was chemically treated, the supernatant decanted, and the thickened septage vacuum filtered alone or in combination with thickened waste activated sludge. Filter yield, cake composition and filtrate characteristics were monitored. For each filter run, the cake formation time, drying time and vacuum pressure were periodically changed.

The study also included an analysis of effects of neutral pH adjustment after chemical treatment; filtration of acid treated septage with and without polymer conditioning; and effects of adding untreated septage to thickened waste activated sludge.

The cost of chemically treating septage and adding it to the solids handling train at Medfield was compared with the cost of adding septage to the liquid train (adding it directly with incoming sewage) as reported in Volume One: Monitoring Septage Addition to Wastewater Treatment Plants.

Heavy metals in sludges, cakes and filtrates were monitored to assess concentrations and the extent of metal association with liquid and solids fractions.

LITERATURE REVIEW

Thickening and dewatering of septage has been investigated by a number of researchers (2, 3, 4, 5).

Feige, et al.,[(2)] Tilsworth,[(5)] and Perrin[(3)] found that raw septage settled poorly, if at all. Perrin[(3)] found that aeration for as long as one month was required before settling improved significantly. Condren[(4)], using screened raw septage, also observed poor separation by settling alone.

In an effort to improve separation, chemical coagulation-flocculation schemes using various conditioning agents have been investigated (2, 4, 6, 7). Condren[(4)] used alum, ferric chloride, ferric chloride-lime, and acidification with sulfuric acid. He found that very high chemical dosages and two-stage acid-lime coagulation were needed to produce a high quality supernatant. Following separation, the sludge was dewatered using sand beds, pressure filtration, solid bowl centrifugation, or cloth belt vacuum filtration. He concluded that sand bed and pressure filtration worked best.

Tilsworth[5] found that solids-liquids separation could only be achieved using very high chemical dosages. For example, lime requirements were approximately 10,000 mg/l. Feige, et al. [2] had to add similar quantities of lime (about 0.090 kg/kg dry solids) in order to achieve acceptable septage dewatering on sand drying beds.

Shaboo[6], using either alum or sulfuric acid, was able to:

1. effect good solids-liquid separation;
2. produce a relatively clear supernatant with substantially reduced contaminant concentration, and
3. dewater the thickened septage satisfactorily on laboratory scale sand beds.

His samples were all rapid mixed for one minute, slow mixed for twenty minutes and settled for 22 hours prior to decanting and placement on the sand beds.

Crowe[7] investigated septage dewatering without prior settling and supernatant decanting. He vacuum filtered septage and mixtures of septage and digested municipal sludge that had been treated with lime, ferric chloride and polymers. He found that mixtures of digested sludge and up to 20 percent raw septage by volume were readily dewatered.

Perrin[3] used capillary suction time (CST) as a laboratory measure of dewaterability and found that raw septages with CST's of 125 to 825 seconds could be successfully lowered to 50 seconds through the addition of either ferric chloride, alum, and some polymers. Septages with CST values of 50 seconds or lower were satisfactorily dewatered on sand beds.

For approximately twelve years the community of Islip, Long Island, has chemically treated raw septage with ferric chloride and lime and dewatered the sludge on a coil belt vacuum filter. Septage is screened, degritted and sent to an equalization basin before chemicals are added to a flash mixer. Solids-liquid separation occurs in a clariflocculator. Chemical requirements average about 0.095 kg lime/kg solids and 0.21 liters of standard strength ferric chloride solution/kg dry solids. Cake production rates are good, cakes are relatively dry and release from the coil very well.

The total chemical cost of ferric chloride and lime treatment was estimated at \$2.04/cu m (\$7.70/1000 gal) of septage. These estimates were based upon chemical costs and average septage concentrations used in this study: $FeCl_3$ cost \$0.795/ℓ

($165.50/55 gal drum), lime cost $0.198/kg ($0.09/lb) and average septage solids concentrations were 11,550 mg/l (96.3 lb/1000 gal).

Summary of Volume One[1]

In Volume One of this report the effects and costs of high septage loadings were examined at treatment plants located at Medfield and Marlborough, Massachusetts and on the University of Lowell campus. Large quantities of septage were fed to the plants on both continuous and shock loading schedules. Process changes, influent and effluent quality were monitored. Monitored characteristics included organic, nutrient and solids concentrations, plant operating parameters, biological indicators and sludge production.

In Volume One it was concluded that septage is readily treated biologically with domestic sewage and the organic and solids content of septage averages about 50 times that of domestic sewage. The efficiency of septage solids separation in primary clarification was demonstrated. It was shown that vacuum filtration was only affected to the extent that more solids must be processed when septage is added to the liquid stream. The studies at Lowell, Medfield and Marlborough indicated that aeration capacity is likely to be the critical parameter in a plant's capacity for treating septage. The septage receiving capacity of a plant can be determined by assuming septage has an average BOD of 6,000 mg/l, and oxygen utilization for septage treated with sewage is the same as for sewage alone. In Medfield and Marlborough utilization averaged about 0.7 kg O_2/kg BOD_5.

The liquid stream study (Volume One) indicated that thickener and vacuum filter design for extended aeration and conventional activated sludge plants can be based upon total anticipated solids in the combined influent sewage and septage with septage contributing 50 times that of an equivalent volume of sewage.

Practical difficulties inherent in handling and treating septage were discussed in Volume One and these are included in Section 6 of this Volume.

SECTION 2

SUMMARY AND CONCLUSIONS

SUMMARY OF RESEARCH

The purpose of this research was to determine the feasibility of dewatering chemically conditioned septage, alone and in combination with thickened waste activated sludge. The research encompassed laboratory experimentation with a filter leaf apparatus and field experimentation with a Komline-Sanderson coil spring vacuum filter. The chemical conditioners used independently for septage treatment were aluminum sulfate (alum), ferric chloride and sulfuric acid.

Laboratory Experiments

The laboratory work was divided into five tasks, A through E. In Task A optimum dosages of Al(III), Fe(III) and H_2SO_4 were determined for ten different septage samples. Septage settling characteristics, Capillary Suction Time (CST) levels and supernatant characteristics were examined. The results of Task A experiments indicated optimum Al(III) dosages between 100 and 180 mg/l, iron dosages between 220 and 400 mg/l as Fe(III) and optimum acidification for conditioning between pH2 and pH3. A tenfold reduction in supernatant COD and total solids concentration was observed with optimum chemical treatments.

Treated septage sludge samples were vacuum filtered in Task B, on a filter leaf apparatus. Various cake form and drying times, and vacuum pressures were used. Cake dryness and yield and filtrate quality were monitored. The leaf tests showed the feasibility of forming cakes on a simulated coil spring filtering medium and appreciably the same results were obtained with the three chemical conditioners.

In Task C the pH of conditioned septage sludges and supernatants were adjusted to pH7. This was done to protect dewatering equipment from corrosion. The tests showed that pH adjustment with lime had little or no effect on dewaterability as measured by the CST Test.

In Task D, septage was combined with thickened waste activated sludge, TWAS, and vacuum filtered on the leaf apparatus. Two modes of combination were used:

Mode I - Septage was chemically treated and settled. The thickened septage was mixed with TWAS, polymer was added and the mixture was vacuum filtered.

Mode II- Septage and TWAS were combined then chemically treated with coagulant or acid and polymer.

Septage and TWAS were combined in ratios of 20% septage to 80% TWAS and 50% septage to 50% TWAS on a total solids basis. Cake dryness, yield and filtrate characteristics were monitored.

Task D tests showed that the same results were accomplished with Modes I and II but twice the quantity of chemical was required for Mode II. The test showed the feasibility of dewatering conditioned septage in combination with TWAS and that comparable results were obtained with either the aluminum or iron coagulants or with acidification.

Heavy metals in conditioned septage sludges and supernatants were monitored in Task E. These laboratory tests showed that Cd, Cr, Cu, Ni, Pb and Zn associate with the solids after treatment with either iron or alum coagulants. Acid conditioning tended to increase metal concentration in the supernatant, particularly Cd and Ni.

Field Experiments

Ten vacuum filter tests were conducted with a full-scale vacuum filter at the Medfield, Massachusetts wastewater treatment plant. Septage was conditioned with either acid, alum or ferric chloride. In each test chemicals were mixed with about 45.5 cu m (12,000 gal) of septage. The septage was settled, the supernatant decanted and the conditioned septage sludge either fed directly to the vacuum filter or combined with TWAS. The mixture was then treated with polymer, followed by vacuum filtration. The tests included three experiments with alum: a septage only test, and runs with mixtures containing 14.6% and 55% conditioned thickened septage. Two mixture tests were conducted with ferric chloride conditioned septage: 23.1% and 44.8% septage combinations. Acidified septage was used in three tests, one with a 46.7% septage/ 53.3% TWAS mixture and the others with only septage - one with polymer, the other without. For comparison a filter run on thickened waste activated sludge was monitored and in a final test a quantity of untreated septage was added to TWAS and the mixture vacuum filtered.

Cake yields, cake solids concentrations and filtrate quality were monitored in filter runs, during which vacuum pressures and drum speeds were varied.

The costs of treating septage in both the liquid and solids trains at Medfield, were determined.

CONCLUSIONS

Coil spring vacuum filtration of a combined mixture of thickened waste activated sludge and septage conditioned with either alum, ferric chloride or sulfuric acid is feasible. This research showed conclusively that excellent cake yields were obtained with combined mixtures having up to 55% septage solids content. Cake release and filtrate quality were good. In fact, when conditioned septage was added to thickened waste activated sludge its dewatering characteristics were improved. The cost of treating septage in the solids handling train at the Medfield, Massachusetts wastewater treatment plant was between $1.79/cu m ($6.76/1000 gal) and $4.04/cu m ($15.28/1000 gal). These costs compare with between $2.02/cu m ($8.30/1000 gal) and $5.26/cu m ($19.82/1000 gal) for adding septage with raw sewage at Medfield.

The laboratory and field studies also showed:

1. Conditioned septage, by itself is not dewaterable on coil spring vacuum filters. Fines in the septage rapidly clog the filtering medium.

2. The CST of conditioned septage sludge was always higher than thickened waste activated sludge values. But, when conditioned septage was combined with TWAS and polymer added, CST levels comparable to polymer treated TWAS were achieved.

3. Based upon observed dewaterability of the conditioned septage/TWAS mixture, the inability to dewater conditioned septage alone and the CST results stated in item 2, it is hypothesized that when septage was mixed with TWAS, fine septage particles were incorporated into the biological flocs. The net effects of combining septage particles and TWAS was the ability to dewater septage with vacuum filtration and enhancement of TWAS filtration.

4. Laboratory filter leaf tests showed that conditioned septage should be amenable to vacuum filtration. The coil spring filter leaf model overestimated cake yields subsequently obtained in the field when filtering only conditioned septage. The filter leaf apparatus

underestimated yields obtained with combined septage and TWAS mixtures. The leaf apparatus also overestimated obtainable cake dryness.

5. Based upon experience with the leaf apparatus and full scale testing it is concluded that the leaf apparatus had limited application for scaling-up purposes but did indicate feasibility.

6. The CST measurement is an effective way of determining optimum coagulant dosage for vacuum filtration.

7. Based upon ease of handling, quality of filtrate, cake yield and cost, alum treatment is the method of choice.

RECOMMENDATIONS

1. This research did not investigate the limits of the septage/TWAS ratio nor were binder materials other than TWAS studied. It is recommended that these are worthwhile areas for study.

2. Full-scale implementation of an alum treatment system is recommended for wastewater treatment plants. The system should include, properly designed septage storage, mixing and pumping equipment, chemical feeders and facilities for combining conditioned septage with TWAS for vacuum filtration. The system should be designed to permit the flexibility of liquid stream as well as solid stream addition.

SECTION 3

LABORATORY TEST RESULTS

TASK A - DETERMINATION OF OPTIMUM CHEMICAL DOSING

Aluminum potassium sulfate, ferric chloride and sulfuric acid were added separately, to ten different septages. The chemicals were added to series of 1 000 ml samples in the dosages shown in Table 1.

TABLE 1. CHEMICAL DOSAGES USED IN TASK A

Chemical	Dosage Range
Aluminum Potassium Sulfate	80 to 800 mg/l as Al(III)
Ferric Chloride	100 to 400 mg/l as Fe(III)
Sulfuric Acid	to pH 2 and pH 3

The range of dosages selected for each test was based upon alkalinity and estimated septage strengths. Septage strength was appraised visually. Chemical dosage selection began at 80 mg/l of either Fe(III) or Al(III) when measured alkalinity was less than about 400 mg/l. At alkalinity levels above 600 mg/l the selected chemical dosage range began at 100 to 120 mg/l. CST (Capillary Suction Time) of settled septage sludges were used to determine optimum coagulant dosages or pH adjustment. Analyses were conducted on raw septage, raw thickened septage, raw septage supernatant, treated septage before settling and thickened septage and supernatant after settling.

Characterization data for raw septage and thickened septage prior to treatment are shown on Table 2. The full set of compiled test results are included as Appendix A of this report. The data in Table 2 show that septage used for this laboratory study had comparatively high solids and organic content. Measured CST values of both the mixed septage and settled sludge (before chemical addition) were very high. This indicated that these materials would not filter well. The settled

TABLE 2. CHARACTERISTICS OF RAW SEPTAGE AND RAW THICKENED SEPTAGE - TASK A

Analysis	Raw Septage $\bar{x}$ *	Raw Septage s **	Raw Thickened Septage $\bar{x}$	Raw Thickened Septage s
COD, mg/l	36 770	13 600	49 880	15 350
Total Solids, mg/l	29 840	12 180	55 880	21 640
Total Volatile Solids, mg/l	19 910	6 410	37 310	8 820
pH	6.2	0.5		
Alkalinity, mg/l as $CaCO_3$	1 090	698		
CST (Capillary Suction Time)	295	113	234	88
Settling Cone, ml Sludge/ml total			465/930	110/20

* Average values
** Standard deviations

portion of the raw septage occupied about half of the total sample volume and had about twice the solids concentration of the mixture prior to settling.

Total solids and total volatile solids measurements of mixed samples (replications of the raw septage measurements) after chemical addition show that chemical additives increased the weights slightly. The values shown in Table 2 for total and volatile solids are the results of more than 280 analyses.

CST values for mixed septage samples (before settling) were markedly changed by chemical conditioning. These changes are shown on Figure 1, as functions of chemical additives and dosage. Figure 1 shows average values for Al(III) and Fe(III). CST was a function of initial solids concentration and alkalinity as well as chemical dosage. Acid quantities used to reach pH values of 2 or 3 were also dependent upon alkalinity and solids concentrations. While a trend of increasing chemical

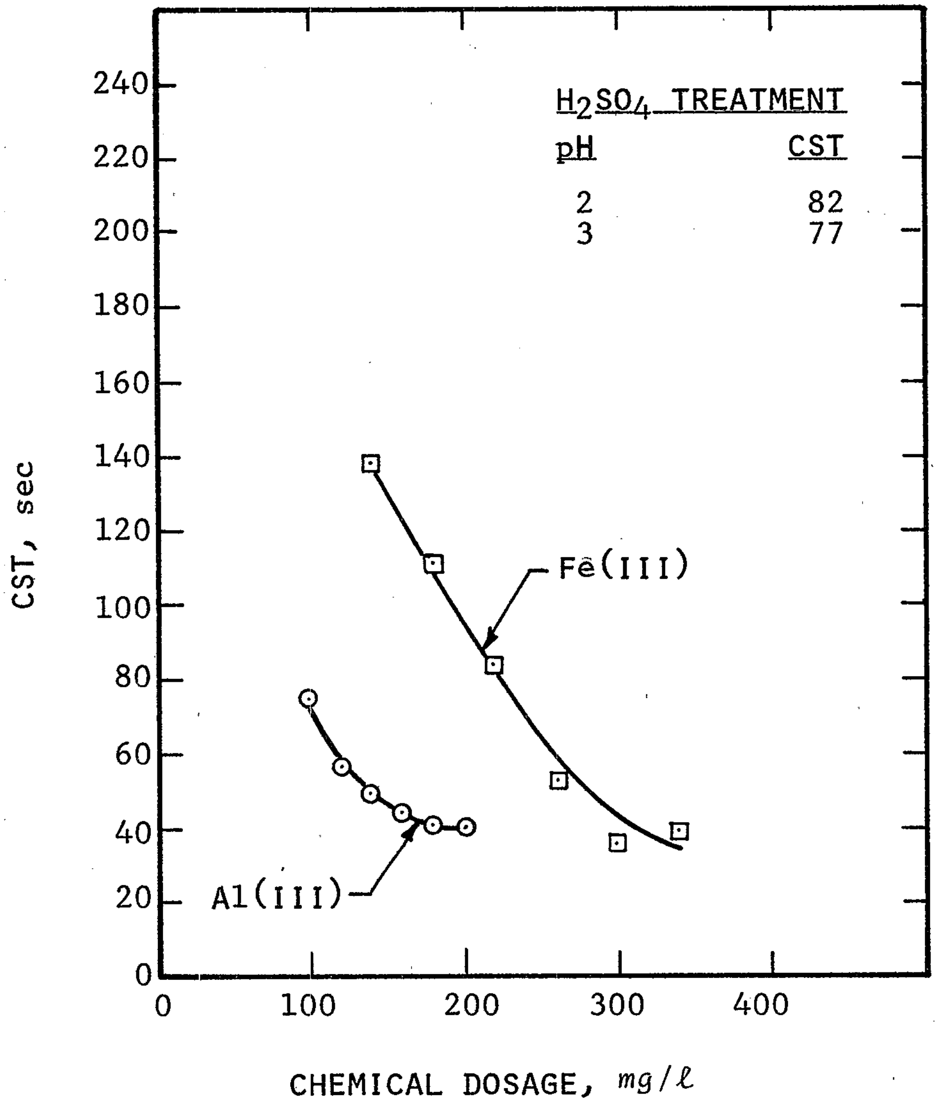

Figure 1. CST vs. chemical dosage for mixed chemically-treated septage, Task A.

requirements and initial CST was observed with increasing alkalinity and initial solids concentration, no definitive relationships were discernible.

The optimum range for the aluminum coagulant was between 100 and 180 mg/l as Al(III) and between 220 and 400 mg/l as Fe(III) for the iron coagulant. Optimum pH values for acidification were between 2 and 3. The addition of either 100 mg/l of Al(III) or Fe(III) caused about a 1 unit drop in initial septage pH. Any Additional 100 to 200 mg/l of coagulant used caused a further reduction of about 0.5 pH unit.

Task A was conducted to determine optimum chemical dosing for vacuum filter tests. Either the mixed conditioned septage or the settled portion of the septage can be filtered. To examine both prospects, analyses were conducted on both mixed and chemically settled sludge. Supernatant quality was monitored.

Solids concentrations in settled septage sludge were about the same as observed without chemical addition. Type and quantity of chemical additive did not influence sludge solids concentrations. The average total solids concentration after chemical conditioning and settling was 52,850 mg/l; the average volatile solids concentration was 35,260 mg/l. The results were based on a total of 280 analyses, and compare with averages of 55,880 mg/l and 37,310 mg/l for total and volatile solids, respectively, before conditioning. Sludge volumes in settling cones were about 50% of the total volume both before and after chemical addition. However, increased supernatant clarity after chemical addition indicates additional solids incorporation in the settled sludge.

CST values for the thickened septage are shown on Figure 2. A comparison of this figure and Figure 1 shows average CST values 20 to 60 units higher for thickened samples than for the mixed unsettled samples. This was due to the increased solids concentrations in the settled samples. Since CST is, at best, an indirect measure of filterability, no comparison was made of CST values for the Al(III), Fe(III) and acid treated samples. However, a comparison of chemical treatments was made using the filter leaf apparatus in Tasks B and D and in the field tests conducted at the Medfield wastewater treatment plant.

Relationships between initial septage total solids concentration, coagulant dosage and CST are shown in Figures 3 and 4. Data for each coagulant dosage were fitted to an exponential curve. Coefficients of determination, r^2, for the least squares curves, averaged 0.58 for the alum treatment and 0.23 for the ferric chloride treatment. The fitted exponential curves, plotted on Figures 3 and 4, are transposed on Figures 5 and 6, where CST is shown as a function of dosage for septages with varying initial total solids content. The results shown on these last two exhibits can be used to approximate chemical dosage requirements.

Supernatant COD is shown as a function of chemical addition in Figure 7 and results of solids analyses are shown in Figure 8. At optimum dosages, supernatant COD and solids con-

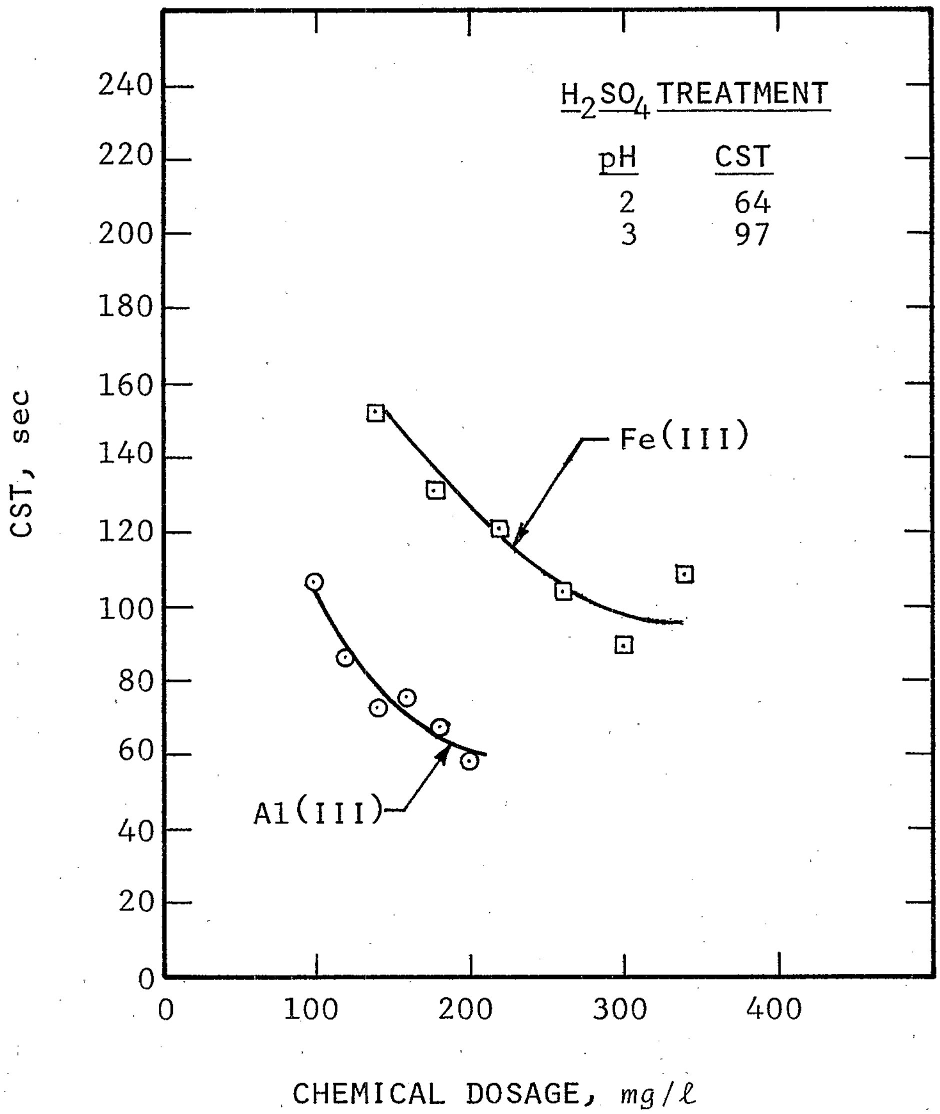

Figure 2. CST vs. chemical dosage for thickened septage, Task A.

centrations were a full order of magnitude less than raw septage concentrations. Increasing chemical dosages generally resulted in decreasing COD and supernatant solids concentrations but this effect was minor when compared with the ten-fold reductions that occurred with the initial 100 mg/l of either Al(III) or Fe(III). Solids concentration in acidified sample supernatant was on the average more than twice as high as obtained with the iron and aluminum coagulants.

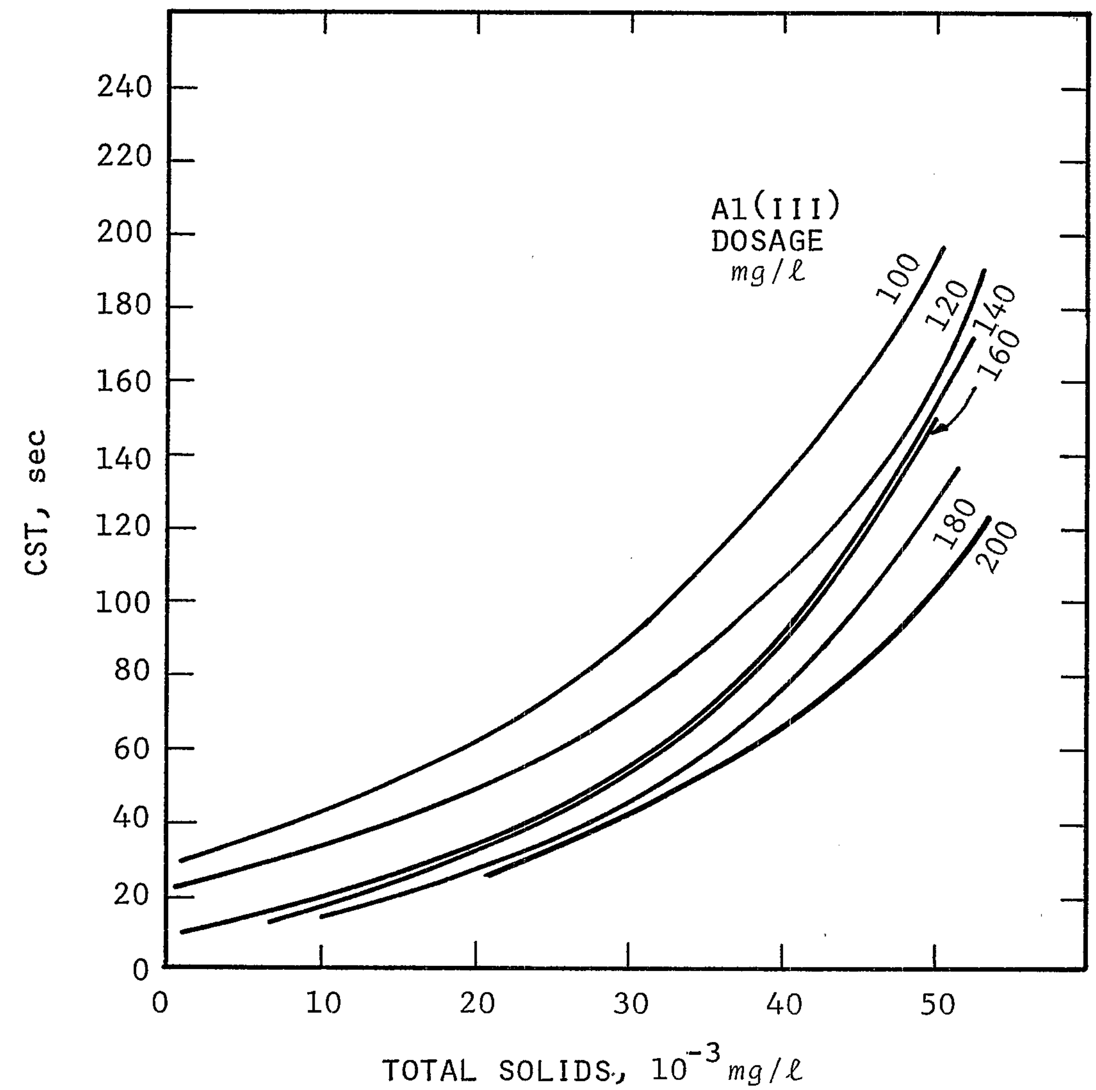

Figure 3. CST vs. total solids and Al(III) dosage, Task A.

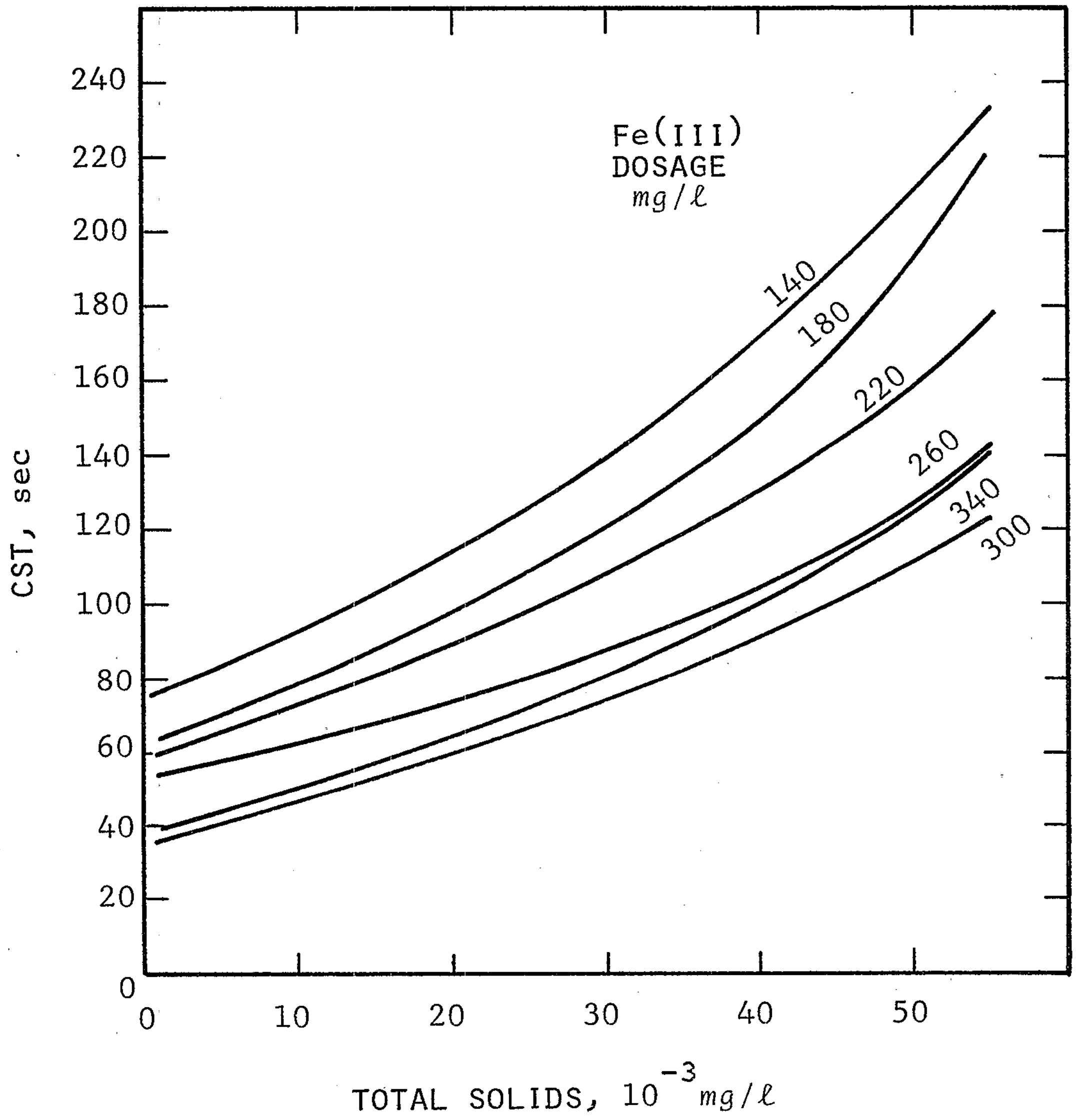

Figure 4. CST vs. total solids and Fe(III) dosage, Task A.

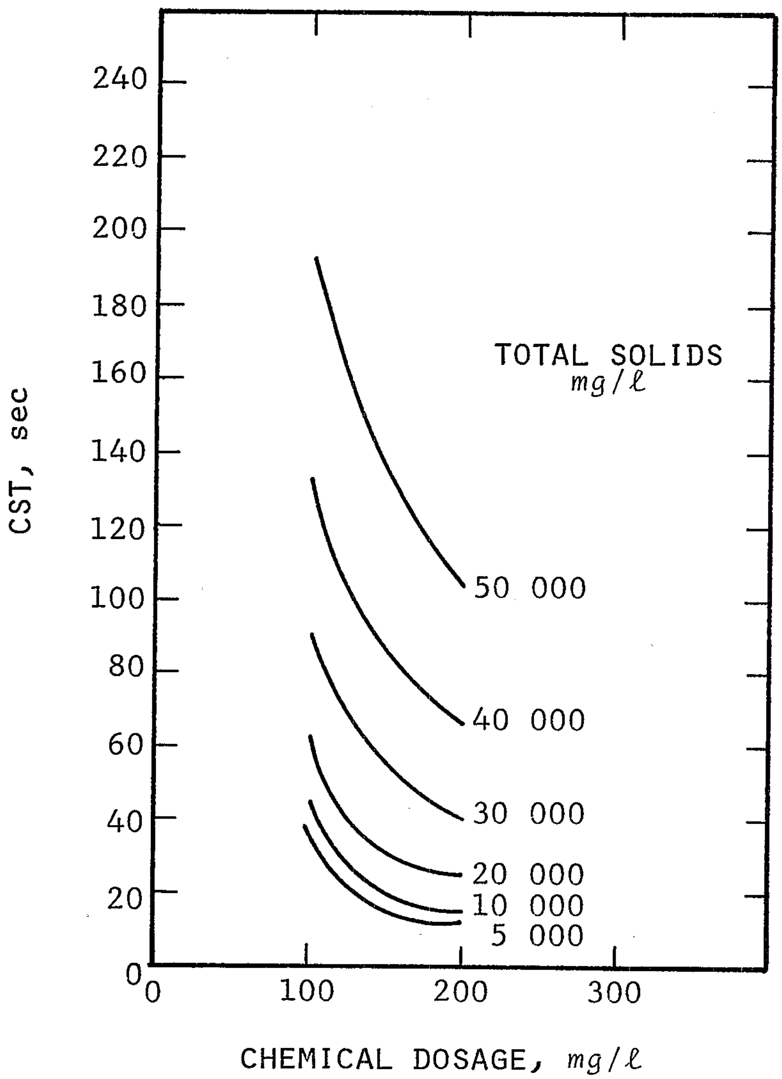

Figure 5. CST as a function of Al(III) dosage and septage total solids concentration, Task A.

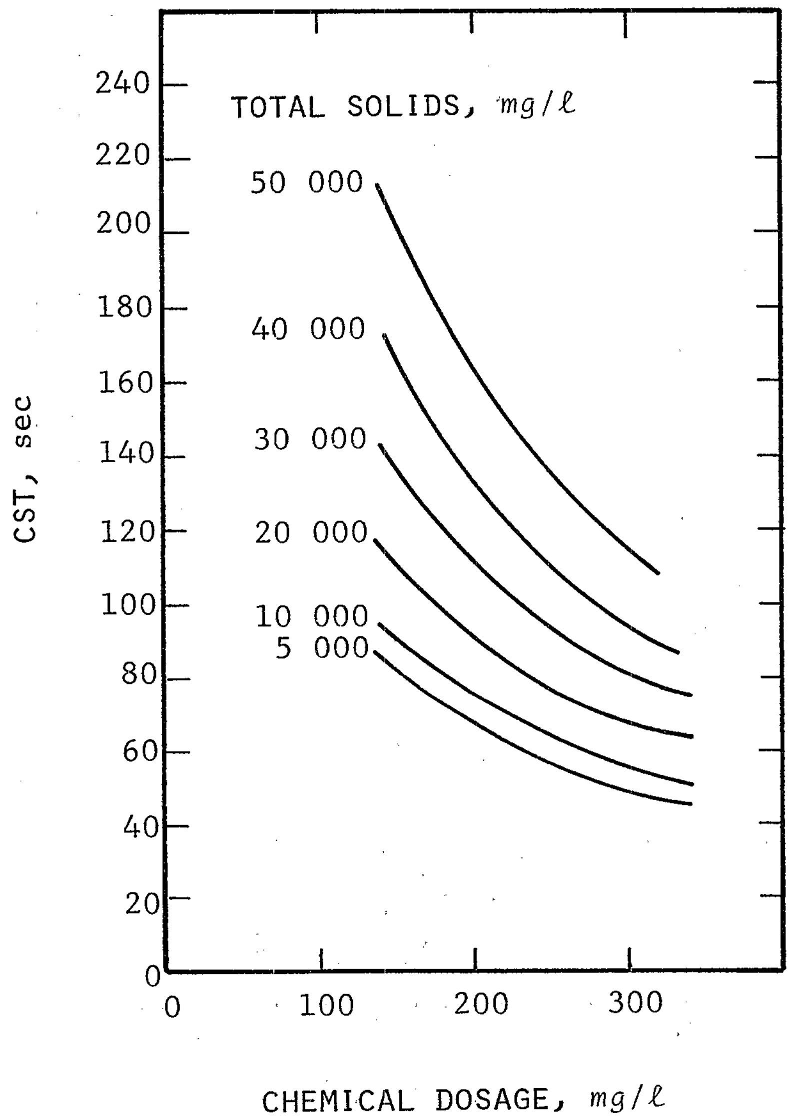

Figure 6. CST as a function of Fe(III) dosage and septage total solids concentration, Task A.

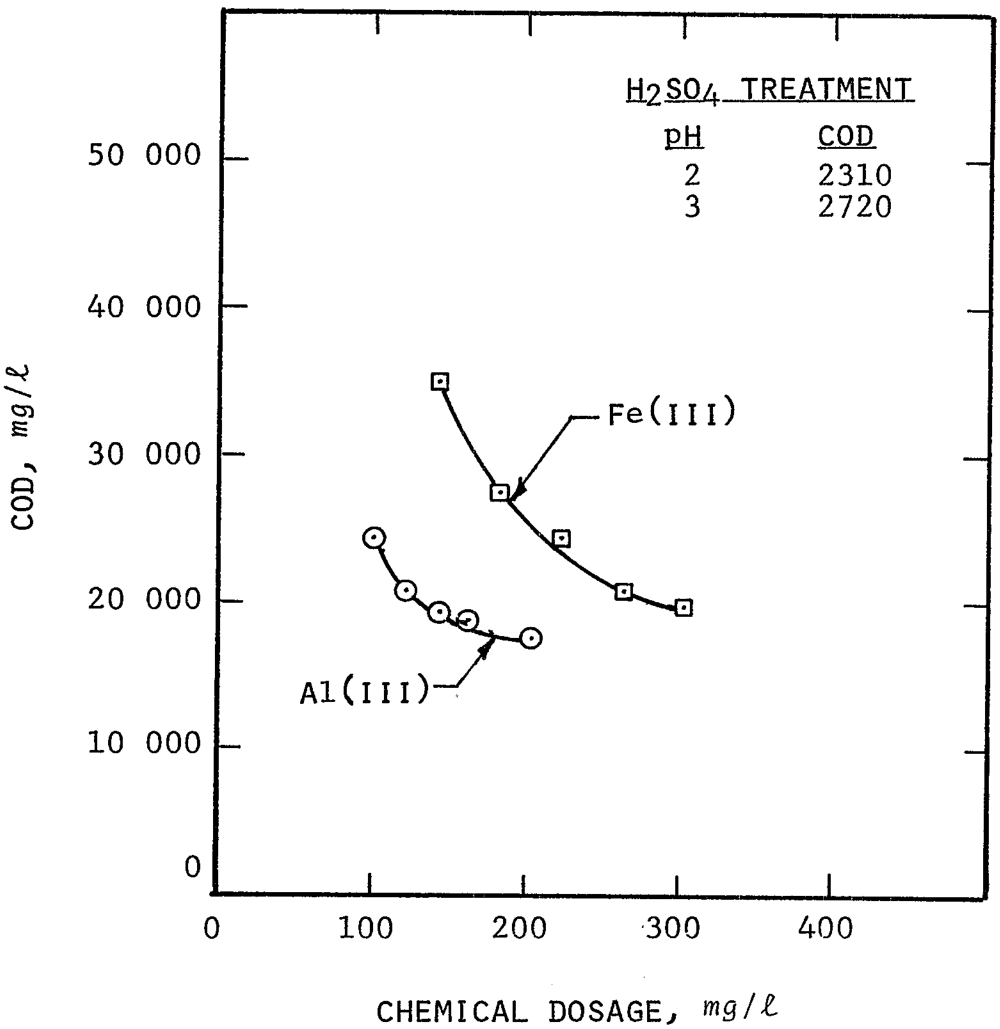

Figure 7. Supernatant COD vs. chemical dosage, Task A.

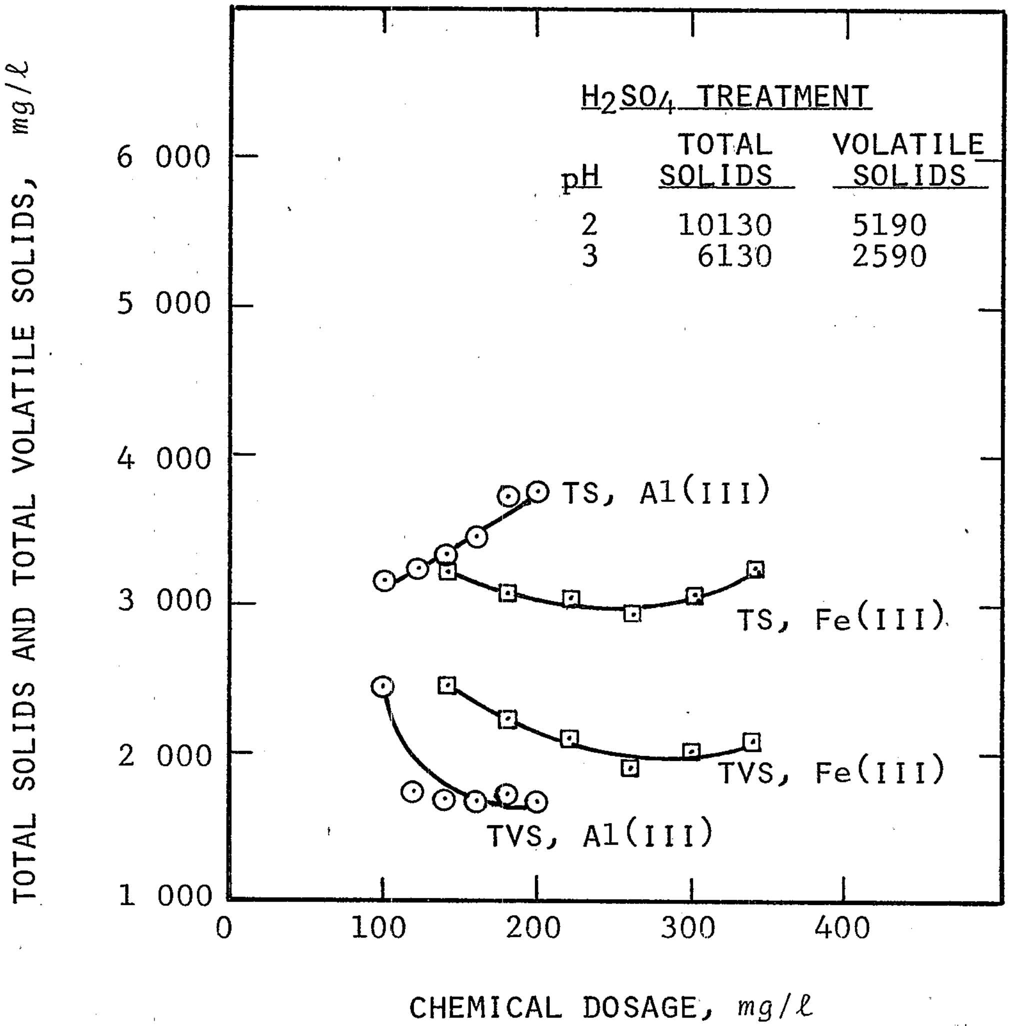

Figure 8. Supernatant solids concentrations vs. chemical dosage, Task A.

TASK B - VACUUM FILTRATION OF CONDITIONED SEPTAGE SLUDGE

Thickened septage samples, obtained from experimentation in Task A, were filtered using a filter leaf apparatus. The device simulates a coil spring vacuum filter and was obtained from the Komline-Sanderson Company. The filter membrane was the K-S standard reference screen which has a 93 sq cm (0.1 sq ft) filtering area. Figure 9 is a schematic diagram of the test apparatus.

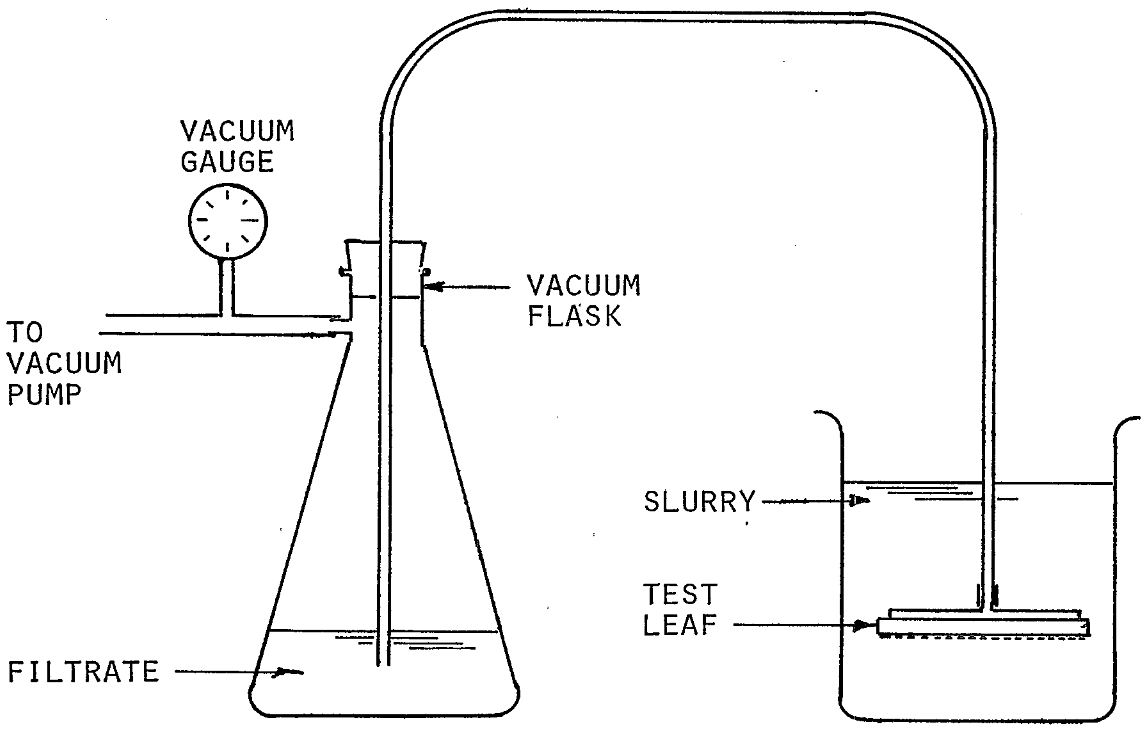

Figure 9. Coilfilter leaf test apparatus.

Thickened septage samples tested with the filter leaf apparatus were those treated at optimum chemical dosage. Each of the ten thickened septage samples, treated independently with Al(III), Fe(III), or acid at optimum dosage, were filtered at 52 kPa (7.5 psi) and 103 kPa (15 psi) and at 1, 2 and 4 minute form-times. One hundred and eighty filter leaf tests were conducted in Task B on thickened septage. Measured characteristics included cake thickness, dry cake weight, percent total solids, percent total volatile solids and cake yield.

Task B results, for percent total solids and cake yield, are summarized in Table 3. The complete results are shown in Appendix B of this report. Total volatile solids averaged 72% of total solids and cake thickness and dry weights were consistent with the cake yields shown in Table 3. Greater yields were obtained with increased pressure but after the first minute of forming little additional solids capture was observed. This is indicated by a sharp decline in yield,

TABLE 3. FILTER LEAF TEST CAKE RESULTS - TASK B

	Cake Total Solids* %			Cake Yield* lb/sq ft-hr**		
Form Time, min	1	2	4	1	2	4
Aluminum Potassium Sulfate						
103 kPa(15psi)	24.5	27.5	29.5	1.37	.66	.36
52 kPa(7.5psi)	22.0	24.0	26.3	.92	.57	.30
Ferric Chloride						
103 kPa(15psi)	24.7	27.6	30.2	1.20	.53	.29
52 kPa(7.5psi)	22.3	24.6	25.5	.90	.51	.23
Sulfuric Acid, pH2-pH3						
103 kPa(15psi)	27.4	29.8	31.7	1.11	.51	.32
52 kPa(7.5psi)	23.9	25.7	26.4	.82	.33	.16

* Ten Sample Averages
** 1 lb/sq ft-hr = 4.844 kg/sq m-hr

almost in an inverse proportion to changes in form-time. Essentially the same yields and percent solids were obtained with the aluminum potassium sulfate, ferric chloride and the acid treatments.

Leaf test filtrate characteristics are summarized in Table 4 and shown fully in Appendix B. Filtrate total solids and COD concentrations were about the same at all form-times and vacuum pressures. Filtrate COD was slightly less in samples treated with Al(III) than with either acid for Fe(III). Filtrate total solids were considerably higher in acidified samples than in samples treated with aluminum or iron.

TASK C - NEUTRAL pH ADJUSTMENT AFTER CONDITIONING

Ferric chloride and aluminum potassium sulfate are salts of strong acids and weak bases and thus tend to depress pH below 7 when added to septage. The acidic conditions caused by these coagulants can in time corrode a vacuum filter. Sludges acidified with sulfuric acid are, of course, highly corrosive. The objective of Task C was to readjust sludge samples to a pH of 7 after chemical treatment and sedimentation as a means of protecting dewatering equipment. Lime was added to thickened septage and supernatant samples obtained from Task A. The

TABLE 4. FILTER LEAF TEST FILTRATE RESULTS - TASK B

	Filtrate COD* mg/l			Filtrate Total Solids* mg/l		
Form Time, min	1	2	4	1	2	4
Aluminum Potassium Sulfate						
103 kPa(15psi)	8630	9380	8800	6350	7130	6920
52 kPa(7.5psi)	12290	10430	9860	9050	7900	7090
Ferric Chloride						
103 kPa(15psi)	9300	10790	11070	5590	7660	7860
52 kPa(7.5psi)	14600	13240	11770	10220	9420	7910
Sulfuric Acid, pH2-pH3						
103 kPa(15psi)	12280	12270	11240	11930	11390	11690
52 kPa(7.5psi)	13700	13070	12050	12030	11310	10250

* Ten Sample Averages

supernatant samples were adjusted to see if any additional separation would occur which would tend to improve supernatant clarity. Lime increased the average total solids concentration in the septage sludge from 52,850 mg/l, found in Task A, to 56,360 mg/l.

CST values for treated and pH adjusted thickened septage are shown in Figure 10 and Table 5. The non-adjusted data obtained in Task A are shown for comparison. Figure 10 shows that CST values for alum treated sludges averaged about 30 CST units above those obtained for the unlimed samples. A similar result was observed with the ferric chloride treatment. Results obtained for the first nine tests with acidified samples, shown in Table 5, indicates that pH adjustment with lime had no effect on CST.

Table 6 shows the effects of adding lime to supernatant samples. pH adjustment had no effect on the samples of supernatant obtained from treatment with either aluminum or iron. However, the acidified supernatant clarity was improved by the addition of lime. COD, total solids and volatile solids concentrations were reduced by lime addition but total solids levels were still double values obtained with the Al(III) and Fe(III) treatments.

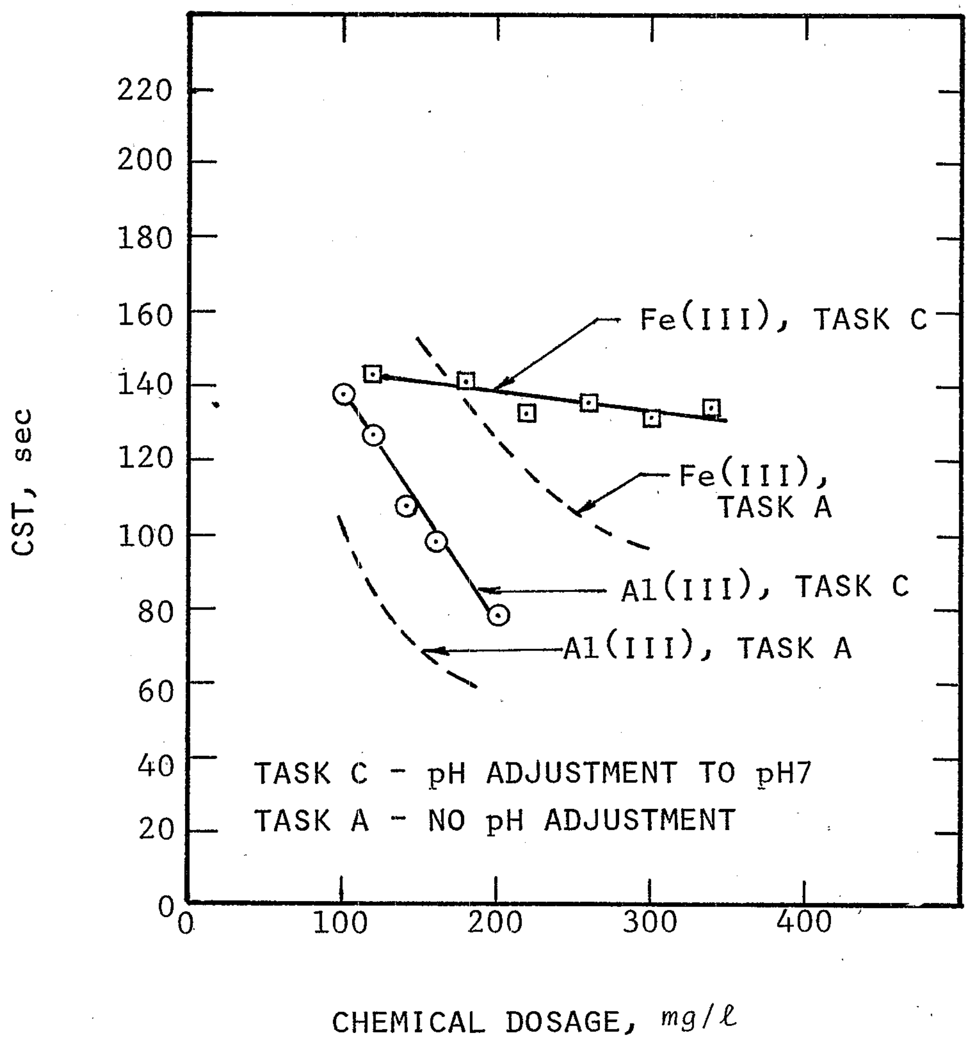

Figure 10. CST vs. chemical dosage for treated septage, Task C.

TABLE 5. CST OF ACID TREATED SEPTAGE SLUDGES WITH AND WITHOUT pH ADJUSTMENT - TASK C

pH After Coagulant or Acid Treatment	pH After Lime Addition	CST $\bar{x}$*	CST s**	Task
2	2	67	29	A
2	7.0	49	53	C
3	3	103	65	A
3	7.0	82	63	C

*Average
**Standard Deviation

TABLE 6. SUPERNATANT CHARACTERISTICS FOR pH ADJUSTED AND NON-ADJUSTED SAMPLES - TASK C

Treatment	COD, mg/l	TOTAL SOLIDS, mg/l	VOLATILE SOLIDS, mg/l
Al(III)			
No pH adjustment	2130	2440	840
pH adjusted to 7	1970	3560	920
Fe(III)			
No pH adjustment	2360	2160	1150
pH adjusted to 7	2490	2610	1190
H_2SO_4, pH2			
No lime adjustment	2490	11560	6020
pH adjusted to 7	1820	8000	1020
H_2SO_4, pH 3			
No lime adjustment	2770	6970	2940
pH adjusted to 7	1600	5860	1150

TASK D - VACUUM FILTRATION OF SEPTAGE AND TWAS

Septage samples, combined with thickened waste activated sludge (TWAS) were dewatered on a filter leaf apparatus. The apparatus used for this task and for Task B is shown in Figure 9. Septage and thickened waste activated sludge were combined in ratios of 20% septage to 80% TWAS and 50% septage to 50% TWAS, on a solids weight basis.

Two procedures were used for combination and treatment. For the first procedure, Mode I, septage and TWAS were chemically treated separately, the septage settled and then thickened septage and TWAS were combined for dewatering. Septage was treated with acid or coagulant and the TWAS was treated with Nalco 7120 polymer. In the second procedure, Mode II, septage and TWAS were combined prior to treatment with coagulant and polymer and no settling or decanting employed.

After chemical treatment the combined sludges were filtered. Cake thicknesses, dry weights, percent total and volatile solids were determined and cake yields were computed. These data are tabulated in Appendix D. Appendix D also includes TWAS and filtrate characteristics.

A summary of results for Mode I (chemical treatment before combination) is shown in Table 7. This table shows total solids and cake yield averages for the 20%/80% and 50%/50% combinations at three form-times and at two vacuum pressures.

Table 7 indicates the following:

1. Increased vacuum pressure did not affect percent solids in the 20%/80% samples but caused about an 18% increase in percent solids in the 50%/50% samples.

2. Cake yield was the same at 103 kPa (15psi) and at 52 kPa (7.5psi).

3. Cake dryness increased with increasing form-time.

4. Cake yields declined almost in proportion to increases in form-time. This indicates that only small amounts of material accumulated after the first minute of forming.

5. A comparison of cake dryness and yield values for the three chemical treatments indicates little difference in the observed results. Yields were low and about the same in all three cases.

6. A comparison of mixture compositions indicates that dryer cakes were obtained with the 50%/50%. This was expected since septage solids would tend to add weight to a cake. However, better yields were obtained with the 20% septage/80% TWAS mixture, indicating better pick-up and cake thickness.

The results of Mode II (septage and TWAS combination before treatment) are summarized in Table 8. The results of the Mode II testing are very similar to what was achieved in Mode I and the above stated results for Table 7 are also appropriate for Table 8. Total solids concentrations were again higher for the 50%/50% mixtures than for the 20% septage/80% TWAS mixtures. Cake yields were again superior for the 20%/80% mixtures.

A comparison of Tables 7 and 8 shows yields about the same for the 20%/80% mixture for both chemical addition procedures. For the 50%/50% mixtures adding coagulant or acid prior to combination of septage and TWAS was advantageous. However, in all cases yields obtained on the filter leaf apparatus were very low when compared with customary full-scale

TABLE 7. FILTER LEAF TEST, CAKE YIELDS - TASK D

MODE I - SEPTAGE TREATED BEFORE COMBINATION WITH THICKENED WASTE ACTIVATED SLUDGE (TWAS)

% Septage/ % TWAS	TOTAL CAKE SOLIDS, % 20%/80%			TOTAL CAKE SOLIDS, % 50%/50%			CAKE YIELD, lb/sq ft-hr* 20%/80%			CAKE YIELD, lb/sq ft-hr* 50%/50%		
Form Time (min)	1	2	4	1	2	4	1	2	4	1	2	4
Al(III)												
103 kPa (15psi)	9.9	11.0	12.3	15.5	15.9	23.3	1.35	.80	.45	.97	.50	.27
52 kPa (7.5psi)	9.4	11.4	12.0	13.4	15.3	16.7	1.35	.78	.40	.82	.39	.25
Fe(III)												
103 kPa (15psi)	10.0	10.6	11.8	14.2	16.5	18.3	1.15	.72	.41	.76	.41	.25
52 kPa (7.2psi)	9.2	10.2	11.2	11.9	14.2	16.8	1.16	.66	.41	.73	.38	.20
H_2SO_4 pH2-pH3												
103 kPa (15psi)	10.5	11.3	12.5	17.8	18.5	21.3	1.23	.70	.47	.82	.38	.22
52 kPa (7.5psi)	10.5	11.3	12.6	13.9	16.8	18.1	1.22	.75	.44	.68	.33	.18

* 1 lb/sq ft-hr = 4.844 kg/sq m-hr

TABLE 8. FILTER LEAF TEST, CAKE YIELDS - TASK D

MODE II - CHEMICAL TREATMENT OF SEPTAGE AND THICKENED WASTE ACTIVATED SLUDGE (TWAS) AFTER COMBINATION

	TOTAL SOLIDS, %						YIELD, lb/sq ft-hr*					
% Septage/ % TWAS	20%/80%			50%/50%			20%/80%			50%/50%		
Form Time (min)	1	2	4	1	2	4	1	2	4	1	2	4
Al(III)												
103 kPa (15psi)	12.4	14.6	15.4	22.5	18.9	23.9	1.23	.63	.35	.56	.30	.15
52 kPa (7.5psi)	11.4	13.5	15.1	15.4	16.7	19.2	1.12	.66	.35	.55	.26	.16
Fe(III)												
103 kPa (15psi)	13.0	14.6	17.2	19.1	20.9	22.2	.90	.52	.27	.48	.23	.14
52 kPa (7.5psi)	11.4	13.5	14.9	18.2	17.8	19.5	.95	.57	.34	.45	.21	.11
H_2SO_4, pH2-pH3												
103 kPa (15psi)	15.4	17.7	19.9	20.6	23.1	24.6	.86	.48	.27	.34	.17	.11
52 kPa (7.5psi)	14.4	15.9	18.1	16.7	19.1	21.1	1.82	.50	.27	.36	.18	.09

*1 lb/sq ft-hr = 4.844 kg/sq m-hr

vacuum filter yields. In part this was due to the low polymer dosages used in the laboratory tests. Chemical treatment after combination, Mode II, did improve cake dryness. Percent total cake solids were higher in Mode II than in Mode I.

About twice the quantity of chemical was needed to perform the Mode II tests for a prescribed quantity of septage since coagulant or acid was added to TWAS and septage. Based upon the similarity of results in Tables 7 and 8 it was concluded that septage treatment prior to combination with TWAS, Mode I, is a preferable procedure for field implementation.

A comparison of Task B and Task D results indicates that conditioned septage alone filters as well as it does in combination with TWAS. These results were later contradicted by field testing.

Summaries of filtrate characteristics for Task D are shown in Tables 9 through 12. The complete results are included in Appendix D. Tables 9 through 12 indicate the following:

TABLE 9. FILTER LEAF TEST FILTRATE RESULTS, TASK D, MODE I, 20% SEPTAGE, 80% TWAS

	Filtrate COD mg/l			Filtrate Total Solids mg/l		
Form Time, min	1	2	4	1	2	4
Al(III)						
103 kPa (15psi)	4300	5310	4760	4540	5190	4660
52 kPa (7.5psi)	5140	3860	3460	5040	3500	3900
Fe(III)						
103 kPa (15psi)	6630	6260	5040	6210	5850	4640
52 kPa (7.5psi)	5710	4070	3330	5190	3600	2840
Sulfuric Acid, pH2-pH3						
103 kPa (15psi)	5240	4970	4570	5330	5050	4450
52 kPa (7.5psi)	5020	3490	3460	4720	3850	3040

TABLE 10. FILTER LEAF TEST, FILTRATE RESULTS, TASK D MODE I, 50% SEPTAGE/50% TWAS

	Filtrate COD mg/l			Filtrate Total Solids mg/l		
Form Time, min	1	2	4	1	2	4
Al(III)						
103 kPa (15psi)	5790	5350	4950	4820	5090	4790
52 kPa (7.5psi)	6260	4940	4350	5660	4120	3620
Fe(III)						
103 kPa (15psi)	7150	6850	6460	6240	5740	5510
52 kPa (7.5psi)	7640	6490	5490	6350	5380	4600
Sulfuric Acid, pH2-pH3						
103 kPa (15psi)	7340	7430	6300	6660	6540	6090
52 kPa (7.5psi)	8170	6240	5460	7680	6150	5180

TABLE 11. FILTER LEAF TEST, FILTRATE RESULTS, TASK D MODE II, 20% SEPTAGE/80% TWAS

	Filtrate COD mg/l			Filtrate Total Solids mg/l		
Form Time, min	1	2	4	1	2	4
Al(III)						
103 kPa (15psi)	5050	5480	5200	5660	5930	5840
52 kPa (7.5psi)	5080	4210	3700	5870	5070	4290
Fe(III)						
103 kPa (15psi)	7220	7150	6130	7430	7070	6120
52 kPa (7.5psi)	5480	5000	4220	6070	4850	4410
Sulfuric Acid, pH2-pH3						
103 kPa (15psi)	8370	7880	7640	9140	10540	9590
52 kPa (7.5psi)	7010	5880	6890	9560	8900	8470

TABLE 12. FILTER LEAF TEST, FILTRATE RESULTS, TASK D
MODE II, 50% SEPTAGE/50% TWAS

	Filtrate COD mg/l			Filtrate Total Solids mg/l		
Form Time, min	1	2	4	1	2	4
Al(III)						
103 kPa (15psi)	6840	7260	6330	7040	7430	7410
52 kPa (7.5psi)	7060	6150	5920	7180	6370	6120
Fe(III)						
103 kPa (15psi)	8130	8330	7850	7350	7450	7400
52 kPa (7.5psi)	7880	7500	6890	6800	6470	6020
Sulfuric Acid, pH2-pH3						
103 kPa (15psi)	10020	9710	8230	13870	13380	12540
52 kPa (7.5psi)	8510	8000	7330	12440	12050	10770

1. COD and total solids concentrations in the leaf apparatus filtrate were more than twice as high as usually experienced when dewatering TWAS with full-scale vacuum filters. Average field test filtrate total solids concentration in this study was 2,800 mg/l; the average concentration measured with the leaf apparatus was 6,400 mg/l.

2. Increased vacuum pressure expectedly resulted in an increase in filtrate solids and COD concentrations.

3. Concentrations decreased with increasing form-time, reflecting a filtering action of deposited material.

4. Filtering combined septage and TWAS with Al(III) produced the best quality filtrate. Results shown for ferric chloride and acid treatments are appreciably higher than aluminum treatment results.

5. Better filtrate quality was obtained with the 20% septage/80% TWAS mixtures than with the 50%/50% mixtures and Mode I gave better results than Mode II.

SECTION 4

FIELD TESTS

EXPERIMENTAL FACILITIES

Field tests for the research were conducted at the Medfield, Massachusetts Wastewater Treatment Plant during the months of July and August 1979. Figure 11 is a schematic diagram of the treatment plant with the processes in use during the experimental period shown with bold lines. Sewage passes through a 56.8 cu m (15,000 gal) aerated grit chamber into the first of four aeration tanks which are in series. The volume of each aeration tank is 302 cu m (80,800 gal). At the average flow rate during July and August, 0.013 cu m/sec, the detention time in the four basins was about 28 hours. The overflow rate in the single 13.1 m (40 ft) diameter final clarifier, in use, was 9.5 cu m/sq m-day (235 gpd/sq ft). The plant was designed for a flow of 0.055 cu m/sec (1.5 mgd). Sewage flow during the study was only 20% of the design flow rate. As a result the primary sedimentation basins were bypassed; aeration basin and final clarifier detention times were long, and loading parameters were low. Thickener and vacuum filters were normally used only one day each week and were available for experimentation. Thickened waste activated sludge used for combination with septage contained no primary sludge. Figure 12 is a schematic diagram of the sludge handling system at Medfield. Thickener, pump and vacuum filter dimensions and operating parameters are given in Table 13.

LIQUID WASTE AND CAKE CHARACTERISTICS

During a monitoring study conducted at Medfield in 1978, under this research contract, plant wastewater streams were monitored for a period of three weeks. The results of that baseline study are valid for operating conditions during this study and are shown in Tables 14 and 15. Total solids concentration in waste secondary sludge averaged about 1%. The CST of this material was very low at 9.1 sec. Table 14 also shows vacuum filter filtrate COD and solids average values that can be compared with the results of the septage filtration tests.

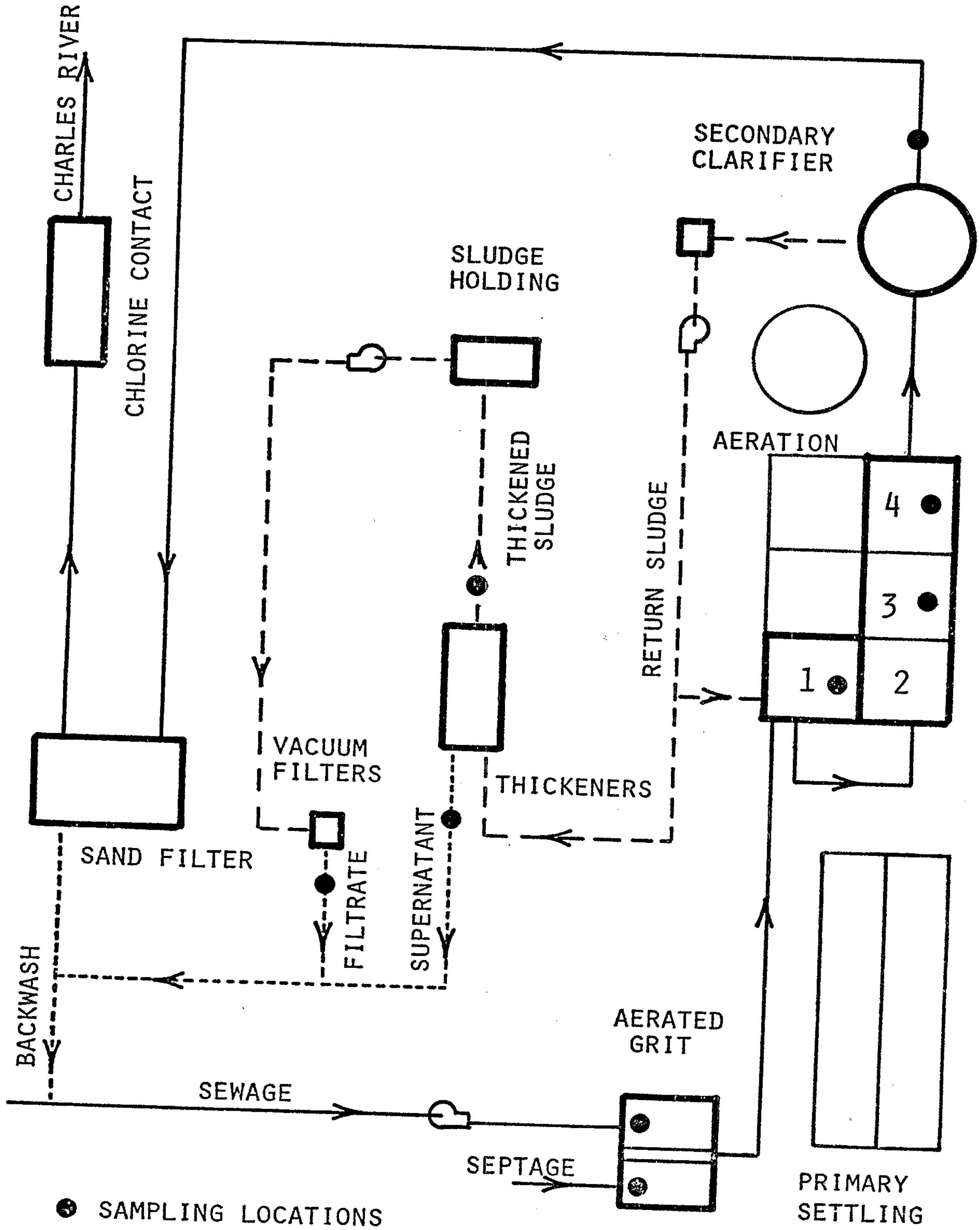

Figure 11. Process schematic - Medfield Wastewater Treatment Plant.

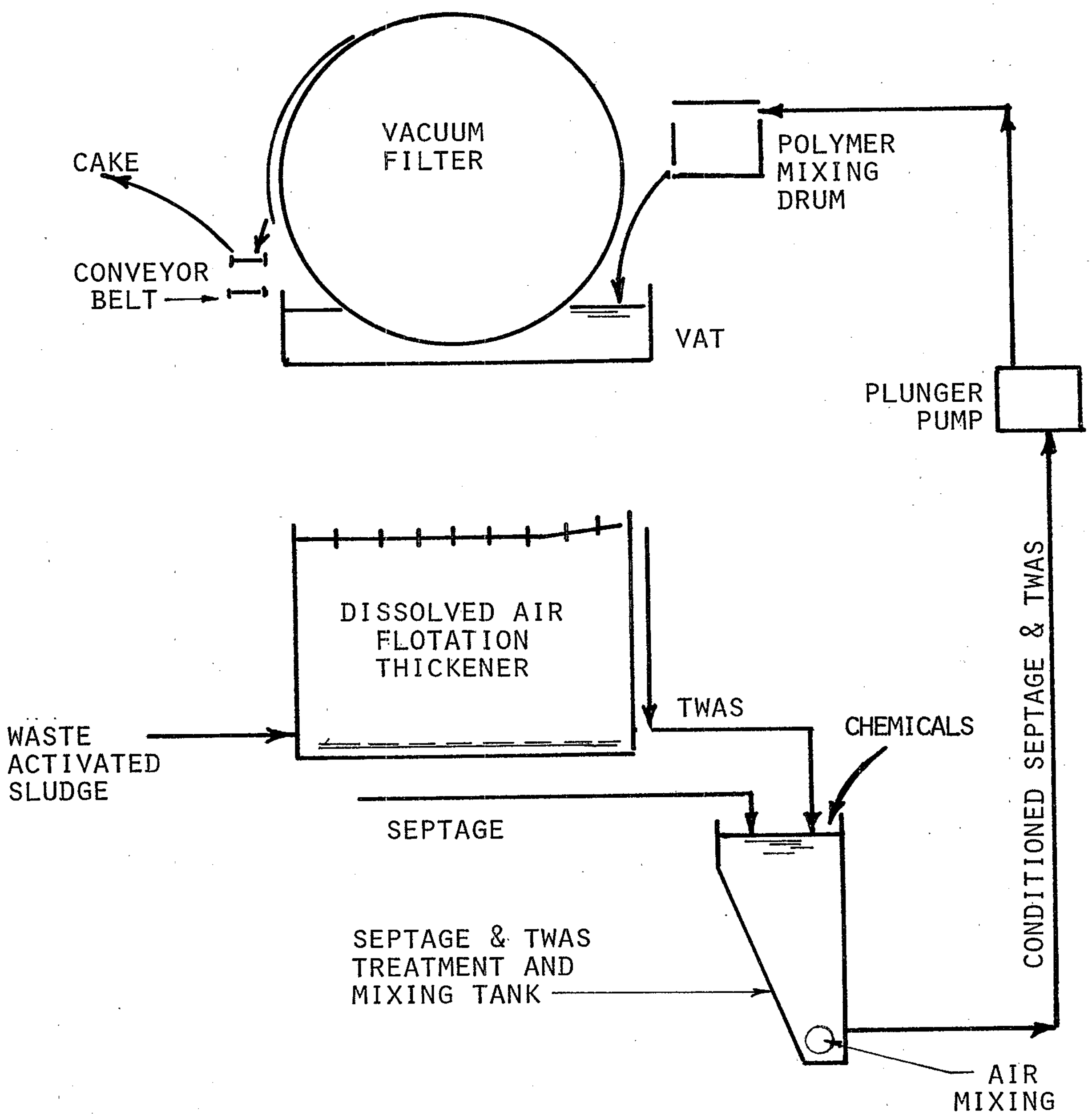

Figure 12. Solids handling train at Medfield.

TABLE 13. VACUUM FILTER DIMENSIONS, MEDFIELD

VACUUM FILTER	
Type:	Coilfilter
Drum Diameter:	1.83 m (6 feet)
Drum Width:	2.44 m (8 feet)
Surface Area:	13.9 sq m (150 sq ft)
Drum Speed:	1 to 10 min/rotation
Filter Springs:	Stainless steel, Rerolled Type 304, 42.5 kg/sq m (8.7 lb/sq ft)
Vacuum Pump:	13.9 cu m/min at 33 cm Hg (490 cu ft/min at 13 inch Hg)

TABLE 14. BASELINE MIXED LIQUOR, SECONDARY SLUDGE THICKENER SUPERNATANT AND VACUUM FILTRATE CHARACTERISTICS (1978)

Characteristics	Mixed Liquor	Secondary Sludge	Thickener Supernatant	Vacuum Filter Filtrate
COD-Total, mg/l			26	358
BOD_5-Total, mg/l			4.4	120
BOD_5-N Suppressed, mg/l			0.7	101
TOC, mg/l			12	91
Total Solids, mg/l	7910	9830	329	768
Total Volatile Solids, mg/l	4670	5850	71	381
Suspended Solids, mg/l	7580		1	83
Volatile Suspended Solids, mg/l	4570		1	55
pH	7.0			
Alkalinity, mg/l as $CaCO_3$	241			
Metals, mg/l				
Cadmium			0.03	0.02
Chromium			0.01	0.08
Copper			0.07	0.15
Nickel			0.09	0.10
Lead			0.45	0.23
Zinc			0.23	1.31
CST, sec		9.1		
30-minute Settlometer, ml/ml total	695/1000	803/1000		

TABLE 15. THICKENED WASTE ACTIVATED SLUDGE AND VACUUM FILTER CAKE - BASELINE STUDY (1978)

Characteristics	Thickened Waste Activated Sludge	Vacuum Filter Cake
Total Solids, %	5.6	12.2
Total Volatile Solids, % of Total	61	61
Volume, cu m/day (gal/day)	5.36 (1420)	
Capillary Suction Time,* (sec)	12	
Metals, mg/kg dry cake		
Cadmium		38
Chromium		306
Copper		1240
Nickel		179
Lead		1330
Zinc		1080

*after polymer treatment

Table 15 shows average thickened waste activated sludge and cake characteristics measured during the baseline period. At an average flow rate of 0.012 cu m/sec (0.28 mgd) during the baseline period the plant produced 185 kg/day (407 lb/day) of dry solids with a cake solids content of 12.2%.

During the course of this septage conditioning and vacuum filtration study with plant flow averaging 0.013 cu m/sec (0.3 mgd) thickened sludge and vacuum filter cake characteristics, shown in Table 16, are similar to values obtained during the baseline period. The results shown on Table 16 were for Test 1, conducted during the same period that chemically treated septages were filtered. Samples of vacuum filter filtrate taken during this test were atypical. During the baseline period filtrate COD averaged 820 mg/l; total solids averaged 1,150 mg/l. Volatile solids were 63% of the total solids concentration.

TABLE 16. THICKENED WASTE ACTIVATED SLUDGE AND VACUUM FILTER CAKE - THIS STUDY, TEST #1

Characteristics	Thickened Waste Activated Sludge	Vacuum Filter Cake
Total Solids, %	4.6	10.3
Total Volatile Solids, %	62	61
CST, sec	16	
Yield, kg/sq m-hr lb/sq ft-hr		12.1 (2.5)

FIELD TEST SELECTIONS

Laboratory experimentation with septage and TWAS indicated that both chemically treated septage and septage combined with TWAS should vacuum filter well. Based upon the laboratory results an initial decision was made to vacuum filter septage alone, treated separately with alum, ferric chloride and sulfuric acid and conditioned septage in combination with treated waste activated sludge. This schedule was modified when it became apparent that chemically treated septage cannot be dewatered on coil spring filters without the addition of thickened waste activated sludge.

Table 17 shows the field test program. Aluminum and acid treated septage was filtered alone without the aid of polymer, as was done in the laboratory tests. The acid treated septage was also filtered with polymer after the failure of the septage-without-polymer test. Septage and TWAS were combined in approximately equal mixtures, on a solids weight basis, after the septage had been treated with either alum, acid or ferric chloride. In addition, tests were conducted with TWAS only, alum added to a 14.6% septage mixture, and iron added to a 23.1% septage mixture. At the request of the plant operators a final test was conducted in which 1.9 cu m (500 gal) of untreated septage was added to 8.3 cu m (2,200 gal) of thickened waste activated sludge.

FIELD TEST PROCEDURES

Septage used for field testing was held in one of two 45.5 cu m (12,000 gal) tanks normally used to hold thickened waste activated sludge prior to vacuum filtration. A diffuser in the tank provided mixing. Septage was either discharged

TABLE 17. VACUUM FILTRATION FIELD TESTS

Test No.	Chemical Treatment	Coagulant Dosage	Septage %	TWAS %
1	Polymer	-	-	100
2	Al(III) & Polymer	80	100	0
3	Al(III) & Polymer	100	14.6	85.4
4	Al(III) & Polymer	130	55	45
5	Fe(III) & Polymer	180	23.1	76.9
6	Fe(III) & Polymer	270	44.8	55.2
7	H_2SO_4 (no polymer)	pH 3	46.7	53.3
8	H_2SO_4 (no polymer)	pH 4.4	100	0
9	H_2SO_4 (with polymer)	pH 3	100	-
10	Polymer	-	1.4	98.6

directly from incoming trucks to the tank or transferred by pump from an aerated grit chamber, where excess septage was stored. Septage was not screened and every effort was made to obtain high solids concentrations. Settlometer and Capillary Suction Time (CST) tests were conducted on septage samples and optimum chemical dosages determined. Based upon these tests required quantities of either acid, alum or ferric chloride were added to full tanks of septage. Septage and chemicals were mixed for 30 minutes and settled for 24 hours. Supernatant was decanted and the treated sludge was either fed directly to the vacuum filter or mixed with TWAS and fed to the filter. Settling cones were used to predict thickened septage quantity and the amount of supernatant to be drawn off. The interface between solids and supernatant was distinct and while pumping supernatant, the liquid darkened quickly upon reaching the interface.

The decision to treat septage prior to mixing with thickened waste activated sludge was based upon the laboratory work which showed that cake yields, cake dryness and filtrate quality were about the same whether chemical conditioning was done before or after combination. The before-combination procedure (Mode I) was used in the field test to reduce chemical usage. In addition, more sample could be treated in the 45.4 cu m (12,000 gal) tank, with pretreatment and decanting prior to combination, because of the need to mix TWAS and conditioned septage prior to filtration.

SECTION 5

FIELD TEST RESULTS

SEPTAGE TREATMENT WITH ALUMINUM SULFATE

On three occasions powdered aluminum sulfate was mixed with about 45 cu m (12,000 gal) of septage. Quantities of septage and thickened waste activated sludge, and the chemical concentrations used in each test are shown in Tables 18 through 23. These tables also show the effects of chemical conditioning and septage/TWAS mixture ratio, on cake production, and supernatant and filtrate quality.

TABLE 18. FIELD TEST RESULTS, SEPTAGE, ALUM TREATMENT

Field Test Number:	2
Test Date:	7/10/79
Mixture:	100% Septage
Chemical Treatment:	80 mg/l as Al(III)
Initial Septage Volume:	47.3 cu m (12,500 gal)
Thickened Septage Volume:	11.7 cu m (3,100 gal)

Characteristic	Raw Septage	Thickened Septage	Septage Supernatant
Total Solids, mg/l	9 950	37 180	950
Volatile Solids, mg/l	7 450	27 190	490
COD, mg/l	16 730	54 150	750
CST, sec	169	40	
pH	6.3	5.0	
Alk, mg/l $CaCO_3$	595		

Alum Conditioned Septage Without TWAS - Test 2

Table 18 shows the effects of adding 80 mg/l of Al(III) to 47.3 cu m (12,500 gal) of septage with an initial total solids concentration of 9,950 mg/l. This concentration of Al(III) was the lowest used in all tests but in the mixed conditioned septage CST was reduced from 169 seconds to 10.3 seconds. Increasing the dosage to 140 mg/l only reduced the CST furthur to 9.7 seconds. The conditioned septage solids settled to 27% of the original volume. The CST was reduced from 169 seconds in raw septage to 40 seconds in the thickened septage. At the initial value the septage could not be vacuum filtered, at 40 seconds filtration should be possible. Decanted supernatant COD and solids concentrations were only about twice that of domestic sewage and constituted an insignificant load on the treatment plant liquid stream. For example, treating a volume of septage equal to 2% of a plant's flow rate would only increase the COD and solids input to the liquid stream by 4%.

Table 19 shows vacuum filter test results. At each selected vacuum pressure and drum rotational speed three samples were taken at ten minute intervals. Form and drying times were dependent upon drum submergence, which ranged from 15 to 25% and averaged about 20%. Drying time averaged 50% and the remaining 30% was release time.

Table 19 shows the characteristics of conditioned thickened septage in the vacuum filter vat, during the course of the test. Average COD and total solids were 54,140 mg/l and 37,180 mg/l respectively. Concentrations were consistent throughout the run and were the same as those measured in the septage holding tank shown on Table 17.

Septage produced a comparatively dry cake but the dry solids yield averaged only 4.75 kg/sq m-hr (0.20 lb/sq ft-hr). Based upon this result coil spring vacuum filtration of alum treated septage, without the addition of thickened waste activated sludge and without polymer is not considered feasible. Cake yields shown in Table 19 progressively decreased during the course of the test. This was caused by granular material in the septage progressively clogging the filter medium. At the end of the septage filter run filtration was attempted with a 50% alum conditioned septage/50% TWAS mixture. This mixture should have filtered well but no cake was produced. After filtration several hours were spent washing the filter medium with a fire hose. This is not normal practice at the plant nor was it necessary after filtering mixtures of septage and thickened waste activated sludge.

The failure of this attempt to vacuum filter conditioned septage is also indicated by the filtrate data, included on

TABLE 19. CAKE AND FILTRATE CHARACTERISTICS SEPTAGE, ALUM TREATMENT

Field Test Number: 2
Mixture: 100% Septage
Chemical Treatment: 80 mg/l as Al(III)

Filtration Pressure, psi*	9	15	15	7	15
Cycle Time, min:sec	8:50	8:50	4:59	4:59	10:14
Vat Contents					
COD, mg/l**	52930	54710	57510	53690	51910
Total Solids, mg/l**	37830	39360	38190	36360	34180
Volatile Solids, mg/l**	27140	28300	28070	26800	25650
pH**	5.6	5.6	5.0	5.4	5.3
Vacuum Filter Cake					
Total Solids, %†	18.6	19.1	20.3	21.3	20.7
Volatile Solids,† % of Total	72.5	75.3	76.6	78.1	78.4
Cake Yield, (lb/sq ft-hr)††	0.32	0.27	0.20	0.14	0.09
Filtrate					
COD, mg/l**	18020	21150	24080	18860	19770
Total Solids, mg/l**	13350	15290	15100	13810	13620
Volatile Solids, % of Total**	69.4	70.7	72.2	72.9	74.0
pH**	5.6	5.9	5.6	5.9	6.0

* 1 psi = 6.9 kPa
**Averages of 3 samples taken at 10 minute intervals
† Averages of 2 samples taken at 10 minute intervals
††Dry solids yield, one sample
1 lb/sq ft = 4.844 kg/sq m

Table 19. Filtrate COD and total solids concentrations were ten times higher than values monitored during both normal filter operation with TWAS (See Table 14) and operation with mixtures of septage and TWAS.

Alum Conditioned Septage Combined with TWAS - Test 3

In the third test 46.6 cu m (12,300 gal) of a comparatively weak septage was treated with 100 mg/l of aluminum sulfate. The settled solids occupied only 5.3 cu m (1,400 gal) at a solids concentration of slightly over 2%.

Experimentation with large quantities of septage over the course of this and previous research has shown that, weak septage, with total solids concentrations between 3,000 mg/l and 7,000 mg/l are the rule. Loads in excess of 20,000 mg/l were seldom encountered in pumpage from domestic septic tanks. This suggests that a large quantity of septage could be held for dewatering by collecting solids in a tank. This could be accomplished by chemically treating and mixing when a tank was full, decanting supernatant, adding more septage and repeating the process.

In Test 3 a thickened waste activated sludge, TWAS was added to the chemically treated septage sludge in a ratio of 14.6% septage to 85.4% TWAS. The measured total solids concentration of the mixture was over 4%. Chemical characteristics of the septage, thickened septage and supernatant, TWAS and the mixture are shown on Table 20.

TABLE 20. FIELD TEST RESULTS, SEPTAGE AND TWAS, ALUM TREATMENT

Field Test Number:	3
Test Date:	7/2/79
Mixture:	14.6% Septage/85.4% TWAS
Chemical Treatment:	100 mg/l as Al(III)
Initial Septage Volume:	46.6 cu m(12,300 gal)
Thickened Septage Vol:	5.3 cu m(1,400 gal)

Characteristic	Raw Septage	Thickened Septage	Supernatant	TWAS	Thickened Septage & TWAS
Total Solids, mg/l	3059	21520	1650	43390	44960
Volatile Solids, mg/l	2073	16150	640	26830	29100
COD, mg/l	4730		920	30040	
CST, sec	48			16	
pH	5.5		4.4	6.9	6.9
Alk, mg/l $CaCO_3$	207				

Polymer was added to waste activated sludge during thickening and it was again added to the septage/TWAS mixture during vacuum filtration. For addition to the septage/TWAS mixture polymer was diluted to 16% of its commercial strength and this solution was fed at a rate of 94.6 ℓ/hr (25 gal/hr). This solution and feed rate were used for all tests employing polymer addition with the exception of Test 10. In Test 10 a 50% stronger solution was used. Polymer was added in all tests except Tests 2 and 8. The results of the vacuum filter test are shown on Table 21. Cake yields averaged 80.7 kg/sq m-hr (3.4 lb/sq ft-hr). This yield was as good or better than usually achieved, treating secondary sludge, at this plant. Table 16 showed a yield of 59.3 kg/sq m-hr (2.5 lb/sq ft-hr) for the initial test with TWAS and no septage. Cake dryness in Tests 1 and 3 (Tables 16 and 21) were about the same. The fairly wet, 10% to 12% solids content, is characteristic of polymer treated secondary sludge. In addition, vacuum pressure on the drying cycle was low during all tests. Attempts to increase pressure were not successful. Yields were slightly improved at the higher drum rotational speeds, indicated by a comparison of the last four columns in Table 21. Filter clogging was not experienced with the septage/TWAS mixture as it was in the previous test - the highest yield was measured at the end of the test period.

Table 21 also shows polymer conditioned septage and TWAS mixture solids content, measured in the vacuum filter vat. These values were consistent with holding tank concentrations.

Filtrate characteristics are also shown on Table 21. The filtrate varied from a relatively clear solution, monitored at 27.6 kPa (4 psi) to a moderately high solids content solution at pressures of 41 kPa (6 psi) and above.

This test showed conclusively that alum treated septage in combination with TWAS in the proportions used, is easily vacuum filtered. Yields were better than average for Medfield and filtrate quality was acceptable.

Alum Conditioned Septage Combined with TWAS - Test 4

Septage was again treated with aluminum sulfate in Test 4 and combined with TWAS after decanting the septage supernatant. The mixture used in this test was 55% septage and 45% TWAS, on a solids weight basis. Table 22 shows septage, TWAS and mixture characteristics. Septage settled to about half of its original volume before decanting. The decanted supernatant was clear with the COD and solids concentrations shown on Table 22, characteristic of alum treated septage. Alum conditioning of the relatively strong septage produced a sludge with better than 4% solids. In combination with TWAS the mixture solids content averaged about 5%. The CST of the initial septage was a high 148 seconds. After conditioning and combination with TWAS the CST was a very low 5.1 sec. A solids

TABLE 21. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE AND TWAS, ALUM TREATMENT

Field Test Number: 3
Mixture: 14.6% Septage/85.4% TWAS
Chemical Treatment: 100 mg/l as Al(III)

Filtration Pressure, psi*	4	4	7	9	4	6
Cycle Time, min:sec	4:41	5:45	5:45	7:27	7:27	4:41
Vacuum Filter Cake						
Total Solids, %**	11.8	12.1	10.2	12.4	10.4	11.3
Volatile Solids, % of Total**	58.7	62.0	61.7	69.0	60.9	56.6
Cake Yield, (lb/sq ft-hr)†		2.0	4.1	3.6	3.1	4.2
Filtrate						
COD, mg/l††	2600	2620	4570	4040	1360	4650
Total Solids, mg/l††	2370	2950	5040	4990	1670	5470
Volatile Solids, % of Total††	52.7	63.3	69.5	61.0	54.9	61.4
pH††	6.7	6.9	6.9	6.9	6.9	6.9

Vat Contents:	Start of Run	Mid-Run	End of Run
Total Solids, mg/l††	17370	40050	49880
Volatile Solids, % of Total††	63.7	63.8	65.0

* 1 psi = 6.9 kPa
** Averages of 3 samples taken at 10 minute intervals
† Dry solids yield, two-sample averages - 1 lb/sq ft = 4.844 kg/sq m
†† Averages of 2 samples taken at 10 minute intervals

TABLE 22. FIELD TEST RESULTS, SEPTAGE AND TWAS, ALUM TREATMENT

Field Test Number:	4
Test Date:	7/12/79
Mixture:	55% Septage/45% TWAS
Chemical Treatment:	130 mg/l as Al(III)
Initial Septage Volume:	43.9 cu m(11,600 gal)
Thickened Septage Vol:	24.2 cu m(6,400 gal)

Characteristic	Raw Septage	Thickened Septage	Super-natant	TWAS	Thickened Septage & TWAS
Total Solids, mg/l	16400	45690	1070	47900	52770
Volatile Solids, mg/l	11760	32620	280	26430	35170
COD, mg/l	27730	60870	810		
CST, sec	148	31		13	5.1
pH	6.3	5.6	6.0	6.5	6.2
Alk, mg/l $CaCO_3$	670				

content of 5%, a CST value of 5.1 seconds and the appearance of the mixture after polymer addition all indicated that the sludge would filter well. Table 23 shows the results of the filter run.

Vat contents in Test 4 were consistent over the course of the run and appreciably the same as in the holding tank. The contents of the holding tank were well mixed with air during the filter run. A comparison of percent volatile solids in septage (72%), TWAS (55%) and the mixture (67%), also shows that no separation of septage and TWAS occurred either in transfer or during filtration.

Cake yields monitored during Test 4 were the highest obtained during the experimental period and were more than double yields normally recorded at Medfield. The maximum yield, 44 kg of dry solids/sq m-hr (9.0 lb/sq ft-hr) was extraordinary and exceeded the capacity of the sludge transfer pump. The diaphragm, thickened sludge transfer pump at Medfield has a maximum capacity of 3ℓ/sec (48 gpm). At maximum pump output and a drum speed of 2 minutes and 32 seconds per cycle the

TABLE 23. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE AND TWAS, ALUM TREATMENT

Field Test Number: 4
Mixture: 55% Septage/45% TWAS
Chemical Treatment: 130 mg/l as Al(III)

Filtration Pressure, psi*	6	6	8	5	8
Cycle Time, min:sec	9:07	5:36	4:00	3:53	2:32
Vat Contents					
Total Solids,mg/l	55200	55220	44530	48690	60200
Volatile Solids, % of Total	67.8	67.1	65.1	66.0	66.9
pH	6.2	6.2	6.3	6.3	6.2
Vacuum Filter Cake					
Total Solids, %**	13.8	12.7	11.5	12.2	12.7
Volatile Solids, % of Total**	67.7	66.7	64.2	62.3	62.1
Cake Yield, (lb/sq ft-hr)†	4.8	5.9	6.9	6.7	9.0
Filtrate					
COD,mg/l**	710	920	1850	1820	2850
Total Solids, mg/l**	940	1210	2290	2290	2830
Volatile Solids, % of Total**	31.6	41.4	54.0	55.6	62.8
pH**	6.6	6.9	6.9	6.9	6.9

* 1 psi = 6.9 kPa
** Averages of 3 samples taken at 10 minute intervals
† Dry solids yield, two-sample averages.
1 lb/sq ft = 4.844 kg/sq m

vacuum filter vat contents were rapidly depleted. The drum was operated at maximum speed. Pressure variation did not appear to affect cake yield but yields were significantly increased by increasing drum speeds. Figure 13 shows cake yield as a function of cycle time. The curve shows an increasing rate of yield with increasing drum speed. It is quite possible that if drum speed could have been increased and sludge pumpage to the filter vat increased, yields in excess of 44 kg/sq m-hr (9 lb sq ft-hr) would have been achieved. The average yield during Test 4 was 32.5 kg/sq m-hr (6.7 lb/sq ft-hr). Cake total solids content averaged 12.6% in this test

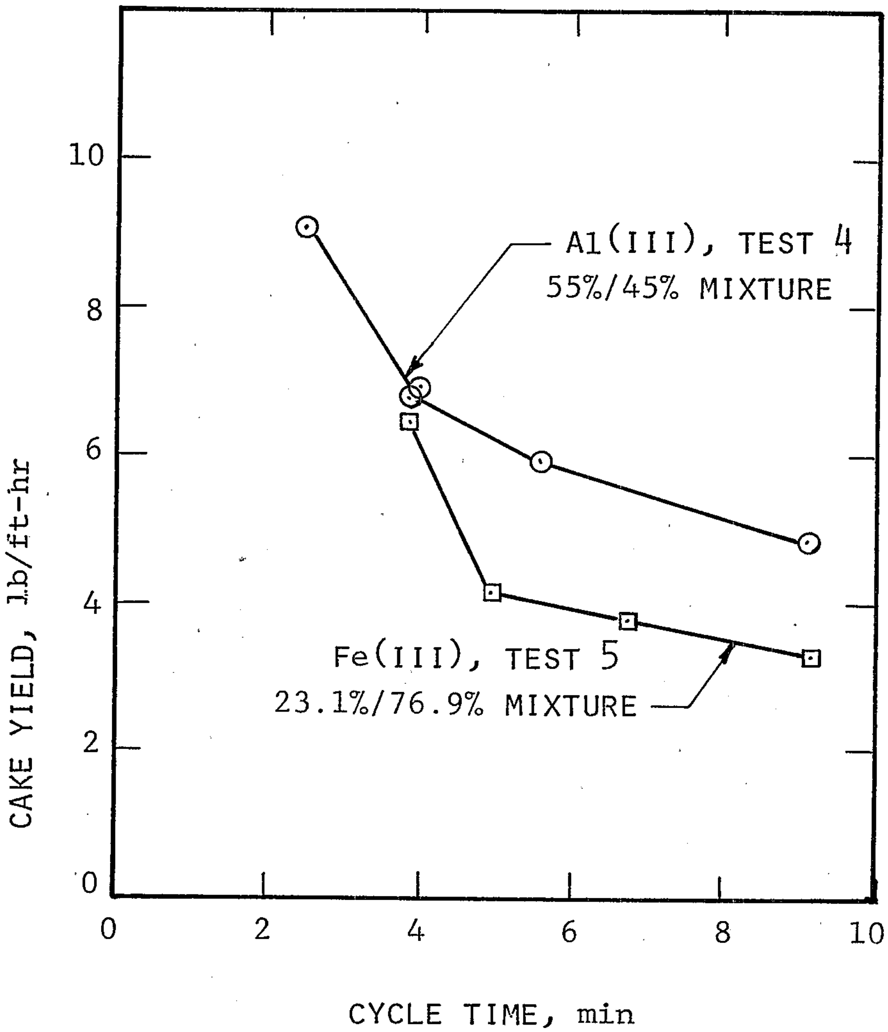

Figure 13. Cake yield vs. vacuum filter cycle time, field test.

as compared with 11.4% for the 14.6%/85.4% mixture test and 10.3% for the Test 1 (TWAS only.) Septage solids increased cake dryness as well as cake yield.

Filtrate COD, total and volatile solids data for Test 4 are also included in Table 23. Filtrate quality was excellent during the entire run but solids content increased steadily with increasing drum speed. Volatile solids data indicate increasing organic solids in the filtrate with increasing rotational speed. At the low speeds the major solids fraction was composed of dissolved inorganic constituents, however, as the drum speed increased particulate organics filtered through the filtering medium.

Field Test 4 showed the feasibility of alum-conditioning and filtering septage in about equal mixture in combination with thickened waste activated sludge. In fact, Test 4 showed that improved cake yields are obtained when alum conditioned septage is filtered with an equal weight of TWAS.

Septage odor was apparent in the vacuum filter building but was not deemed excessive or objectionable by plant personnel. Odor production was substantially increased in later tests conducted at low pH.

SEPTAGE TREATMENT WITH FERRIC CHLORIDE

A 42% solution of ferric chloride was used to condition two quantities of septage prior to combination with TWAS and vacuum filtration. The results of these tests are summarized in Tables 24 through 27: Tests 5 and 6. Septage was treated with Fe(III), settled for 24 hours and the supernatant decanted. The conditioned sludge was combined with thickened waste activated sludge, TWAS, in ratios of 23.1% septage to 76.9% TWAS and 44.8% septage to 55.2% TWAS. Based upon the failure encountered in attempting to filter alum conditioned septage without TWAS, filtration of ferric chloride treated septage was not tried.

Ferric Chloride Conditioned Septage with TWAS - Test 5

Table 24 shows characteristics of the raw and conditioned sludges used for Test 5. Fe(III) treatment reduced the septage to 30% of its initial volume. The supernatant was low in solids and organic content and similar in quality to the alum treated supernatant. Conditioned thickened septage and TWAS had a solids content in excess of 5% and a CST of 6.0 sec. These characteristics and the appearance of the sludge indicated that it should filter well.

Table 25 shows the results of the filter test. Vat contents were maintained at solids concentrations measured initially in the holding tank. Cake yields averaged 21.3 kg/sq m-hr (4.4 lb/sq ft-hr) and reached a maximum of 31 kg/sq m-hr (6.4 lb/sq ft-hr) at a drum speed of 3 minutes and 50 seconds per cycle. This compares with a similar yield of 33 kg/sq m-hr (6.8 lb/sq ft-hr) at a rotational speed of 4 minutes per cycle for the 55%/45% alum treated mixture. However, the yields, although excellent, were less than experienced with alum. Yields monitored in Test 5 are shown on Figure 13. Filtrate

TABLE 24. FIELD TEST RESULTS, SEPTAGE AND TWAS, IRON TREATMENT

Field Test Number: 5
Test Date: 7/17/79
Mixture: 23.1% Septage/76.9% TWAS
Chemical Treatment: 180 mg/l as Fe(III)
Initial Septage Volume: 36.3 cu m(9,600 gal)
Thickened Septage Vol: 10.8 cu m(2,850 gal)

Characteristic	Raw Septage	Thickened Septage	Super-natant	TWAS	Thickened Septage & TWAS
Total Solids, mg/l	5340	28080	1110	51130	55120
Volatile Solids, mg/l	4200	22150	530	30100	35720
COD, mg/l	9270	42500	750	33590	
CST, sec	138			15	6.0
pH	7.2	5.9	5.6	5.6	6.4
Alk, mg/l $CaCO_3$	580				

quality was excellent over the course of the Fe(III) test. However, filtrate solids and COD values increased with increasing drum speed.

Ferric Chloride Conditioned Septage with TWAS - Test 6

A moderately strong septage was used for the second Fe(III) test. Sludge characteristics are shown on Table 26. The combined mixture of 44.8% conditioned septage and 55.2% TWAS had a solids content in excess of 5%. The CST was reduced from 155 seconds in raw septage to 121 seconds in thickened septage and to 5.4 seconds in the conditioned septage-TWAS mixture. The thickened septage CST measurement was considerably higher than values obtained in laboratory experiments. CST measurements of the conditioned septage prior to settling in settlometers at Medfield for chemical dosing between 140 mg/l and 300 mg/l of Fe(III), was between 16.8 seconds and 6.0 seconds.

TABLE 25. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE AND TWAS, IRON TREATMENT

Field Test Number: 5
Mixture: 23.1% Septage/76.9% TWAS
Chemical Treatment: 180 mg/l as Fe(III)

Filtration Pressure, psi*	7	7	7	8
Cycle Time, min:sec	9:13	6:50	4:55	3:50
Vat Contents				
Total Solids, mg/l**	45600	60700	55750	58410
Volatile Solids, mg/l**	30950	40550	35150	36220
pH**	6.2	6.4	6.4	6.4
Vacuum Filter Cake				
Total Solids, %**	13.3	12.8	10.1	10.1
Volatile Solids, % of Total**	62.9	61.9	60.0	57.0
Cake Yield, (lb/sq ft-hr)†	3.3	3.8	4.1	6.4
Filtrate				
COD, mg/l**	770	1060	2390	2550
Total Solids, mg/l**	890	1030	2580	2980
Volatile Solids, % of Total**	48.1	62.4	62.3	61.9
pH**	6.8	6.7	6.8	6.9

* 1 psi = 6.9 kPa
** Averages of 3 samples taken at 10 minute intervals
† Dry Solids yield, two-sample averages.
1 lb/sq ft = 4.844 kg/sq m

Table 27 shows cake and filtrate characteristics measured for the polymer treated, 44.8% septage/55.2% TWAS mixture. Cake solids content averaged 12.2%, yield averaged 19.7 kg/sq m-hr (4.1 lb/sq ft-hr). Cake yield was again excellent and increased with increasing drum speed. Filtrate quality was excellent at the low drum speeds but deteriorated at a rotational speed of 3 minutes and 44 seconds. Volatile

TABLE 26. FIELD TEST RESULTS, SEPTAGE AND TWAS, IRON TREATMENT

Field Test Number:	6
Test Date:	7/20/79
Mixture:	44.8% Septage/55.2% TWAS
Chemical Treatment:	220 mg/l as Fe(III)
Initial Septage Volume:	44.3 cu m(11,700 gal)
Thickened Septage Vol:	15.5 cu m(4,100 gal)

Characteristics	Raw Septage	Thickened Septage	Super-natant	TWAS	Thickened Septage & TWAS
Total Solids, mg/l	11790	25610	1600	49230	51470
Volatile Solids, mg/l	9410	19920	880	31020	35760
COD, mg/l	17810	37580	2760	36860	
CST, sec	155	121		7.0	5.4
pH	6.1	5.2	5.2	6.6	6.0
Alk, mg/l $CaCO_3$	680				

solids values also indicate the increasing organic solids breakthrough with increasing drum speed.

ACID TREATMENT OF SEPTAGE

Three filter runs were conducted with septage that had been chemically treated with sulfuric acid. Septage was acidified to a pH between 2 and 3, settled and the supernatant decanted. In the first test acidified thickened septage was combined with TWAS in a ratio of 46.7% septage to 53.3% TWAS, conditioned with polymer, and filtered. This was followed by two tests with just acidified septage: one with polymer conditioning, the other without.

Acid Conditioned Septage with TWAS - Test 7

Sulfuric acid added to 43.7 cu m (11,550 gal) of raw septage reduced the pH to 3. Settled solids occupied 36% of the initial volume. Combined septage and TWAS sludge had a solids content in excess of 4%, comparable to the alum and ferric chloride treated sludges and adequate for filtration.

TABLE 27. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE AND TWAS, IRON TREATMENT

Field Test Number: 6
Mixture: 44.8% Septage/55.2% TWAS
Chemical Treatment: 220 mg/l as Fe(III)

Filtration Pressure, psi*	7	7	8	9	10
Cycle Time, min:sec	9:35	6:34	4:48	3:44	6:49
Vat Contents					
Total Solids, mg/l**	44360	51220	55130	55160	
Volatile Solids mg/l**	30590	34920	39170	38340	
Vacuum Filter Cake					
Total Solids, %**	14.3	12.8	12.2	10.6	10.9
Volatile Solids, % of Total**	67.3	64.5	63.1	64.6	65.5
Cake Yield, (lb/sq ft-hr)†	3.8	3.9	3.8	4.8	4.0
Filtrate					
COD, mg/l**	1130	1420	2310	5440	2650
Total Solids, mg/l**	1160	1370	2130	4890	2310
Volatile Solids, % of Total**	43.9	53.2	61.2	63.7	55.5
pH**	5.9	6.2	6.2	6.0	6.1

* 1 psi = 6.9 kPa
** Averages of 3 samples taken at 10 minute intervals
† Dry Solids yield, two-sample averages
1 lb/sq ft = 4.844 kg/sq m

Septage CST, shown on Table 28, was reduced to a low value, also comparable with the other types of treatment, and indicative of good filtering sludge.

Supernatant COD and solids content were about twice as high as experienced with the iron and aluminum coagulants. This result was consistent with the laboratory test results. At an organic and solids concentration of about 5 times that of domestic sewage, the supernatant load on the plant was insignificant.

TABLE 28. FIELD TEST RESULTS, SEPTAGE AND TWAS, ACID TREATMENT

Field Test Number:	7
Test Date:	7/24/79
Mixture:	46.7% Septage/53.3% TWAS
Chemical Treatment:	H_2SO_4 to pH 3.0
Initial Septage Volume:	43.7 cu m(11,550 gal)
Thickened Septage Vol:	15.9 cu m(4,200 gal)

Characteristics	Raw Septage	Thickened Septage	Super-natant	TWAS	Thickened Septage & TWAS
Total Solids, mg/l	8480	31720	2440	47780	43360
Volatile Solids, mg/l	6530	26030	1130	27920	31920
COD, mg/l	14330	45670	1860	30709	
CST, sec	116	48		7.0	5.4
pH	5.9	3.8	3.0	6.4	6.4
Alk, mg/l $CaCO_3$	610				

Table 29 shows the results of the filter run. The concentration of the vat mixture increased during the course of the test. This trend observed in this test and to a slight extent in other tests, may have been caused by vacuum dewatering through the submerged belt in excess of the collected cake. Cake yield in this test averaged 18 kg/sq m-hr (3.8 lb/sq ft-hr), which is comparable with the other septage/TWAS test results and better than achieved with only TWAS. The cake produced with acidified septage was significantly dryer than those produced with the chemical coagulants. Percent solids averaged 15.2%. This was the dryest cake obtained in the study.

At comparable drum speeds and septage to TWAS ratios filtrate COD and solids concentrations were about the same with either alum or ferric chloride treatment. Concentrations were higher with acidification. For example with about 50/50 mixtures of septage and TWAS, cycle times between 4 and 9 minutes, filtration pressures between 27 and 62 kPa (6 and 9 psi) filtrate total solids concentrations for alum, ferric chloride

TABLE 29. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE AND TWAS, ACID TREATMENT

Field Test Number: 7
Mixture: 46.7% Septage/53.3% TWAS
Chemical Treatment: H_2SO_4 to pH 3.0

Filtration Pressure, psi*	7	9	10	13	11
Cycle Time, min:sec	8:12	6:13	4:48	3:32	6:30
Vat Contents					
Total Solids, mg/l**	39090	43300	44310	49730	
Volatile Solids, mg/l**	28850	29600	32260	36940	
Vacuum Filter Cake					
Total Solids,%**	14.6	13.6	15.9	16.6	
Volatile Solids, % of Total**	70.4	70.8	71.2		
Cake Yield, (lb/sq ft-hr)†	3.6	3.1	3.6	4.7	
Filtrate					
COD, mg/l**	1310	1840	3370	6060	2990
Total Solids, mg/l**	2010	2640	4050	6060	3540
Volatile Solids, % of Total**	47.2	50.6	57.3	63.4	58.5
pH**	5.0	5.0	4.9	5.0	5.5

* 1 psi = 6.9 kPa
** Average of 3 samples taken at 10 minute intervals
† Dry Solids yield, two-sample intervals
1 lb/sq ft = 4.844 kg/sq m

and acid treatments were 1,480 mg/l, 1,550 mg/l and 2,320 mg/l, respectively. Comparatively, high vacuum pressures, up to 90 kPa (13 psi) were possible during tests with acidified septage but not when alum or ferric chloride was used.

Filtration of Acid Conditioned Septage - Tests 8 and 9

Table 30 shows solids concentrations in sludges used for Tests 8 and 9. The septage settled to 49% of its initial

TABLE 30.- FIELD TEST RESULTS, SEPTAGE, ACID TREATMENT

Field Test Number:	8 and 9
Test Date:	7/26/79
Mixture:	100% Septage/0% TWAS
Chemical Treatment:	H_2SO_4 to pH 2.6
Initial Septage Volume:	38.6 cu m(10,200 gal)
Thickened Septage Vol:	18.7 cu m(4,950 gal)

Characteristics	Raw Septage	Thickened Septage	Super-natant	TWAS	Thickened Septage & TWAS
Total Solids, mg/l	27200	51160	4980		
Volatile Solids, mg/l	18730	36100	1520		
COD, mg/l	38800		2550		
CST, sec	133	66			
pH	5.2	4.2	2.5		
Alk, mg/l $CaCO_3$	980				

volume at pH 2.6. The supernatant was characteristically high in solids content, although extremely strong septage was used for the test. Treated sludge solids content exceeded 5% which is more than adequate for filtration but the high CST indicated poor filterability. The pH of the supernatant was 2.5, prior to decanting. Acid conditioned septage in the vat had a pH of 4.5 in Test 8 and 3.8 in Test 9. This was the result of chemical reactions involving the solid materials.

Table 31 shows the results of the two tests: Test 8, filtration without polymer and Test 9, with polymer added to the sludge. In both tests a slow drum speed was used and the filter was cleaned between tests. The yield in Test 8 was only 3 kg/sq m-hr (0.61 lb/sq ft-hr) and in Test 9 the filter did not produce a cake. In both tests filtrate quality was extremely poor with COD and solids concentrations exceeding 10,000 mg/l.

The two tests demonstrated the infeasibility of filtering acid treated septage, with or without polymer conditioning

TABLE 31. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE, ACID TREATMENT

Field Test Number:	8 and 9	
Mixture:	100% Septage/0% TWAS	
Chemical Treatment:	H_2SO_4 to pH 2.6	
Filtration	Test No. 8	Test No. 9
Pressure, psi*	9**	9***
Cycle Time, min:sec	8:15	8:26
Vat Contents		
Total Solids, mg/l	62280	40030
Volatile Solids, mg/l	44050	28150
pH	4.5	3.8
Vacuum Filter Cake		
Total Solids, %	16.8	18.3
Volatile Solids, % of Total	75.6	76.9
Cake Yield, (lb/sq ft-hr)†	0.61	Not Measurable
Filtrate		
COD, mg/l	15680	17450
Total Solids/mg/l	10430	13730
Volatile Solids, % of Total	66.7	65.8
pH	4.4	3.0

* 1 psi = 6.9 kPa
** No polymer added
*** Polymer added at 150% of normal rate
† Dry solids yield, two-sample intervals
1 lb/sq ft = 4.844 kg/sq m

on coil spring filters. The filters produced little or no cake, clogged rapidly and produced high solids content filtrate.

Thickened Waste Activated Sludge with Untreated Septage - Test 10

In this final test 8.3 cu m (2,200 gal) of thickened waste activated sludge was mixed with 1.9 cu m (500 gal) of untreated septage. The mixture was conditioned with polymer and vacuum filtered. Results are shown in Tables 32 and 33.

TABLE 32. FIELD TEST RESULTS, SEPTAGE AND TWAS, NO TREATMENT

Field Test Number:	10
Test Date:	7/31/79
Mixture:	1.4% Septage/98.6% TWAS
Chemical Treatment:	None other than polymer
Initial Septage Volume:	1.9 cu m(500 gal)
Thickened Septage Vol:	

Characteristics	Raw Septage	Thickened Septage	Super-natant	TWAS	* Thickened Septage & TWAS
Total Solids, mg/l	3030			72430	
Volatile Solids, mg/l	2360			39800	
COD, mg/l	4520				
CST, sec	11				
pH	6.6				
Alk, mg/l $CaCO_3$	290				

*Calculated from raw septage and vat contents values

Septage strength in this test was extremely weak and appeared only to dilute the TWAS and change its color from brown to gray. The polymer feed tank was filled with leftover solution which was fifty percent stronger than that used in the previous runs. As a result coagulation of the mixture resulted in an oatmeal appearance with obvious separation of solids and liquid in the filter vat.

Attempts were made to maintain approximately 25% filter submergence. However, the vat contents became so thick that as the mat formed the sludge in the vat balled up and stripped

TABLE 33. CAKE AND FILTRATE CHARACTERISTICS, SEPTAGE AND TWAS, NO TREATMENT

Field Test Number:	10		
Mixture:	1.4% Septage/98.6% TWAS		
Chemical Treatment:	None other than polymer		
Filtration Pressure			
psi*	6	4	10
Cycle Time, min:sec	10:26	5:31	3:34
Vat Contents			
Total Solids,mg/l**	22590	68430	69220
Volatile Solids, mg/l**	14880	36400	38320
pH**	5.8	5.9	6.0
Vacuum Filter Cake			
Total Solids, %**	13.9	12.1	9.7
Volatile Solids, % of Total**	61.4	51.6	53.9
Cake Yield, (lb/sq ft-hr)†	0.74	5.74	3.84
Filtrate			
COD, mg/l**	1150	690	4830
Total Solids, mg/l**	1430	808	5970
Volatile Solids, % of Total**	55.6	50.0	61.4
pH**	6.3	6.5	6.2

* 1 psi = 6.9 kPa
** Averages of 3 samples taken at 10 minute intervals
† Dry solids yield, two-sample intervals
1 lb/sq ft = 4.844 kg/sq m

the mat from the coils. This definitely reduced the observed yields obtained, although they were highly satisfactory. In order to filter this material optimally it would have been necessary to reduce submergence to perhaps 15%. This was made clear when emptying the vat at the end of the run. As vat depth decreased the cake formed well on the coils - uniformly covering the coils to a depth of 1/2 to 3/4 inch.

TWAS solids concentrations were calculated from mass balance considerations using measured quantities from vat contents and raw septage. TWAS solids concentrations were high because of the ease with which water was withdrawn from this mixture. As filtration progressed liquid was withdrawn leaving solids in the tank, increasing observed concentrations.

Based upon yield, and filtrate quality it is concluded that raw septage, in small quantities, can be combined with TWAS and satisfactorily dewatered. While the solids septage/TWAS ratio was only 1.4%/98.6%, volumetric septage/TWAS ratio was 18.5%/81.5%. Since this test was successfully accomplished using very weak septage it is suggested that results would also have been satisfactory using strong septage.

SECTION 6

SYNTHESIS OF FIELD RESULTS

CAKE YIELD

The vacuum filter at Medfield is normally operated at about 55 kPa (8 psi) and at a rotational speed of 6.5 minutes per cycle. At 25% drum submergence this corresponds to a form time of 1.6 minutes which is the filter manufacturer's recommendation for the Medfield filter. Field Test 1 was conducted with thickened waste activated sludge, at 55 kPa (8 psi) and with the drum rotating once every 6.7 minutes. The cake yield averaged 12.1 kg/sq m-hr (2.5 lb/sq ft-hr).

A comparison of septage and TWAS cake yield for the various types of treatment and septage/TWAS mixtures was made for these normal operating conditions; i.e., 55 kPa (8 psi) and 6.5 min/cycle.

For each filter test, data for vacuum pressures above 41 kPa (6 psi) were statistically analyzed. An exponential least squares curve was fitted through paired yield and cycle time data. The results of these statistical analyses are compared on Table 34 with Field Test 1. Table 34 lists computed cake yields corresponding to a cycle time of 6.5 minutes. Coefficients, r^2, indicate the quality of the least squares fit. The following conclusions can be drawn from the computed yield values shown on Table 34.

1. Septage conditioned with either coagulant or acid could not be filtered unless combined with thickened waste activated sludge. Reduction in cake yields observed during the course of septage only runs was due to filter coil clogging with septage particles.

2. Septage treated with sulfuric acid, ferric chloride or aluminum sulfate when combined in equal weight proportion with TWAS vacuum filtered well on a coil spring medium.

3. Conditioned septage in combination with TWAS produced better yields than normally experienced with just TWAS.

TABLE 34. CAKE YIELD COMPARISON FOR CHEMICAL TREATMENTS AND SEPTAGE/TWAS MIXTURES

Test No.	Chemical Treatment	Type of Sludge	Sludge Total Solids %	Computed Cake Yield lb/sq ft-hr*	Coefficient r^2
1	Polymer	TWAS	4.6	2.5	-
2	80 mg/l Al(III)	Septage	3.7	0.2	-
3	100 mg/l Al(III) & Polymer	14.6% Septage 85.4% TWAS	4.5	3.8	.94
4	130 mg/l Al(III) & Polymer	55% Septage 45% TWAS	5.3	5.8	.93
5	180 mg/l Fe(III) & Polymer	23.1% Septage 76.9% TWAS	5.5	4.1	.75
6	220 mg/l Fe(III) & Polymer	44.8% Septage 55.2% TWAS	5.1	4.0	.42
7	H_2SO_4 - pH 3.0 & Polymer	46.7% Septage 53.5% TWAS	4.3	3.6	.40
8	H_2SO_4 - pH 2.6	Septage	5.1	0.6	-
9	H_2SO_4 - pH 2.6 & Polymer	Septage	5.1	None	

* 1 lb/sq ft-hr = 4.344 kg/sq m-hr

4. The best yields were obtained with aluminum sulfate conditioning and a 55% septage/45% TWAS mixture. Fe(III) and acid conditioning also produced excellent yields.

5. There was a slight correlation between sludge solids concentration and yield (r^2=.33). Within the range of sludge concentrations used, the three types of chemicals produced similar results.

FILTRATE QUALITY

Table 35 shows computed vacuum filter filtrate concentrations. Filtrate concentrations were dependent upon drum speed, chemical treatment, septage/TWAS mixture and to some extent, vacuum pressure and the length of filter run. Values shown in Table 35 are average values.

Average filtrate COD and solids concentrations for conditioned septage filtration, Tests 2, 8 and 9, were 5 to 10 times as high as septage/TWAS mixture concentrations. The mixture results, Tests 3 through 7, were similar to concentration levels usually achieved with just TWAS. The table also includes ratios of average volatile solids concentration in filtrate to the volatile solids content of vat sludge. Low ratios are indicative of good solids removal and reflect a lower proportion of particulates and associated organics in the filtrate.

PRACTICAL CONSIDERATIONS

The three chemical treatments tested in this study worked well. They produced excellent cake yields when conditioned septage was combined with thickened waste activated sludge. Filtrate quality was adequate. Selection of one method for application at an existing or proposed treatment plant should be based upon treatment economics and the particular advantages or disadvantages of each chemical. Treatment economics are covered in Section 8 of this report.

Alum is available in liquid or powdered form. Chemical feeding equipment is readily available. Alum is an easy chemical to handle - it's non-corrosive and non-toxic. Alum sludge pH is only slightly acidic. CST testing is required at various alum concentrations in a jar test apparatus, prior to conditioning large quantities of septage.

Sulfuric acid is a difficult chemical to handle but not unknown to water treatment personnel. The acidified sludge can corrode a vacuum filter unless lime pH adjustment is also used. The conditioning effects of acid were not diminished by the later addition of lime. The advantage of acid treatment is

TABLE 35. FILTRATE COMPARISON FOR CHEMICAL TREATMENTS AND SEPTAGE/TWAS MIXTURES

Test. No.	Chemical Treatment	Type of Sludge	COD mg/l	Total Solids mg/l	Volatile Solids % of Total	Volatile Solids Ratio Filtrate/ Vat Contents
1	Polymer	TWAS				
2	80 mg/l Al(III)	Septage	20400	14200	71.8	1.05
3	100 mg/l Al(III)	14.6% Septage 85.4% TWAS	3310	3750	60.5	.94
4	130 mg/l Al(III) & Polymer	55% Septage 45% TWAS	1630	1910	49.1	.74
5	180 mg/l Fe(III) & Polymer	23.1% Septage 76.9% TWAS	1690	1870	58.7	.91
6	220 mg/l Fe(III) & Polymer	44.8% Septage 55.2% TWAS	2590	2370	55.5	.80
7	H_2SO_4 - pH 3.0 & Polymer	46.7% Septage 53.5% TWAS	3110	3660	55.4	.77
8	H_2SO_4 - pH 2.6	Septage	15680	10430	66.7	.94
9	H_2SO_4 - pH 2.6 & Polymer	Septage	17450	13730	65.8	.94
10	None	1.4% Septage 98.6% TWAS	2220	2740	55.7	1.00

in the simplicity of pH adjustment as compared with jar testing. All septages tested were optimally conditioned between pH2 and pH3.

Acidifying septage has two other distinct disadvantages. Septage odors are significantly more pronounced at low pH and at low pH phosphorus remains in solution returning to the plant in both supernatant and filtrate. The cost of treating this additional phosphorus is shown in Section 8 to be a distinct economic disadvantage.

Ferric chloride has some of the disadvantages of both the alum and the acid. It is difficult to handle, highly corrosive and testing is needed to determine dosage. However, many wastewater treatment plants use ferric chloride in their sludge management scheme.

Chemical selection will depend in large measure upon conditions found at a specific site. These conditions can include: tertiary treatment requirements for phosphorus removal, local chemical costs, available chemical storage and feeding equipment, operator experience and preference.

Septage Handling and Receiving

Large quantities of septage are not easily fed to either the liquid or solids train at municipal treatment plants, unless facilities are constructed or available to accommodate the unique characteristics of this waste. Septage can contain large quantities of grit and stringy material. It is highly odoriferous and is a health hazard. The combination of these characteristics make it a difficult material to pump and pass through constrictions and conduits. Maintenance of improperly designed facilities is objectionable and hazardous. Invariably, when septage handling at a plant is troublesome, haulers are turned away.

New facility design should permit the flexibility of various modes of liquid and solids train addition. Control strategies differ, depending upon the size and type of plant accepting septage, plant sewage and septage loading, excess process capacity, and personnel and budgetary constraints. Generally the most cost-effective way of handling septage is to move it to the dewatering stage with as little dilution as possible.

SECTION 7

HEAVY METALS

DETERMINATION OF METAL LOCATION

Raw septage samples were treated in the laboratory with coagulants and acids. Samples of the raw septage, supernatants and conditioned thickened septages were examined for Cd, Cr, Cu, Ni, Pb, and Zn. Analyses were conducted to determine the total amounts present and their distribution after treatment. A total of 115 samples were analyzed. In most cases, only those supernatants and sludges resulting from optimum chemical dosing were examined. Table 36 shows these results expressed in terms of mg of metal per kilogram of total solids. Values reported in studies conducted by the Environmental Protection Agency are also shown. (8)

TABLE 36. METALS IN RAW SEPTAGE

	mg/kg Total Solids		
	This Study		Lebanon, Ohio
Metal	$\bar{x}$*	s**	$\bar{x}$
Cd	10.0	11.5	5.5
Cr	54.8	22.6	21.0
Cu	570.3	276.9	28.1
Ni	36.1	8.0	28.5
Pb	156.4	85.3	--
Zn	257.0	93.8	1,280.0

*Mean
**Standard Deviation

Table 37 indicates that metals were associated with or incorporated in the solids fraction of septage. Only nickel and cadmium showed increases in the percentage of metal remaining in solution over that of the settled raw septage and then only in samples which were acidified. Samples treated with ferric chloride appeared to remove the greatest amount of metals from the supernatant fraction. This was true of all metals tested.

TABLE 37. PERCENTAGE OF METAL IN SUPERNATANT AFTER INDICATED TREATMENT

Metal	% in Supernatant									
	Control		pH2		pH3		Alum		Iron	
	$\bar{x}$ *	s **	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Cd	9.7	15.5	19.4	27.1	1.5	3.7	7.8	14.5	4.2	11.6
Cr	8.6	13.0	6.7	10.0	2.8	3.1	6.3	14.7	0.5	1.5
Cu	16.3	11.0	0.5	0.9	1.9	2.2	0.3	0.3	0.7	0.3
Ni	19.3	15.8	35.4	20.4	21.8	10.6	13.8	9.1	13.2	6.6
Pb	11.4	15.6	3.1	6.8	5.5	13.5	1.4	2.0	1.1	2.3
Zn	29.1	10.3	15.5	9.2	13.2	7.9	7.2	11.1	4.9	4.1

* Mean
** Standard Deviation

SECTION 8

COST OF SEPTAGE TREATMENT

OPERATING AND MAINTENANCE COSTS

The cost of treating septage through the solids train at Medfield was calculated using the three methods of the earlier study.(1) Method 1 distributed the cost of septage treatment across all items in the treatment plant budget. Methods 2 and 3 distributed the costs over only those items considered to be expressly involved with treatment of septage, i.e., electrical, chemical, truck fuel, motor repair, and personnel costs. In Method 2 plant staff was increased by one person. Septage input was assumed to be 2% of the plant flow. For Method 3, a personnel increase of 19 man hours/week was assumed for the 2% addition of septage.

The following chemical costs were used for these analyses: sulfuric acid, \$0.292/ℓ(\$1.10/gal); alum \$0.317/kg, (\$0.144/lb): and ferric chloride, \$0.795/ℓ (\$3.01/gal) supplied as a 42% solution. Personnel costs were estimated at \$49.20 per day and electrical costs at \$0.066/kw-h. Polymer cost \$0.52/ℓ (\$1.96/gal).

METHOD OF ANALYSIS(1)

Records at the Medfield plant for the period prior to initiation of the research program indicated a fairly consistent addition of about 0.5%, by volume, of septage. This level of addition did not cause any modifications in plant operation, nor any disruption in performance. However, it was a substantial contribution to plant organic and solids loading and provided a baseline condition for estimating the cost of septage treatment. The baseline condition is shown in Table 38.

Method 1 - Budget Item Cost Distribution

The operating budget of the plant was divided into thirteen accounts as shown on Table 39. Each of the accounts was apportioned between four characteristics of the wastewater: flow, organic loading, total solids and phosphorus. Both BOD and COD were used as measures of wastewater organic content.

TABLE 38. MEDFIELD TREATMENT PLANT AVERAGES AND YEARLY TOTALS

Parameter	Influent	Septage	Yearly Totals
Flow	1,135 cu m/day (0.30 mgd)	1,740 cu m/yr (460,000 gal/yr)	416,400 cu m ($110x10^6$ gal)
Organic Loading			
BOD	138 mg/l (156.6 kg/day)	4,664 mg/l (8,115 kg/yr)	65,300 kg/yr (144,000 lb/yr)
COD	293 mg/l (332.5 kg/day)	14,564 mg/l (25,340 kg/yr)	147,000 kg/yr (324,000 lb/yr)
Total Solids	437 mg/l (496 kg/day)	11,549 mg/l (20,100 kg/yr)	201,000 kg/yr (443,000 lb/yr)
Phosphorus	10.9 mg/l (12.4 kg/day)	127 mg/l (221 kg/yr)	4,740 kg/yr (10,440 lb/yr)

TABLE 39. PERCENT DISTRIBUTION - MEDFIELD - METHOD 1

	% Cost Based on Flow	% Cost Based on Organic Loading	% Cost Based on Total Solids Loading	% Cost Based On Phosphorus Loading
Electrical	36	21	42	1
Chemical	10		17.6	72.4
Supplies	30	30	30	10
Outside Services	33	33	33	1
Clean Sewer	100			
Travel	30	30	30	10
Uniforms	33	33	33	1
Telephone	30	30	30	10
Heat	15	15	65	5
Truck Fuel			100	
Motor Repair			100	
Consultant	10	20	60	10
Personnel	15	25	55	5

The cost distribution for Method 1 is shown on Tables 39 and 40. It was fairly easy to apportion power and chemical costs with reasonable accuracy, and these two budget items represent more than 40% of the total cost. The distribution of salaries representing an additional 35% of overall costs, were based upon operator judgment. Some of the other ten budget items are specific to one characteristic of the wastewater, but most can only be distributed arbitrarily according to someone's most reasonable estimate, with due regard to floor space occupied, or in proportion to power consumed, etc. Justification is essentially subjective for these costs.

Unit costs of removal for each wastewater characteristic given on Table 40 were applied to average characteristics of septage. Values for total treatment cost were computed in accordance with:

$$C = \Sigma(v + w \cdot BOD + y \cdot SS + z \cdot P)$$

or

$$C = \Sigma(v + x \cdot COD + y \cdot SS + z \cdot P)$$

where C = the cost of treatment per cu m (1,000 gal) of septage

BOD = the organic loading in kg/cu m (lb/1,000 gal) as biochemical oxygen demand

COD = the organic loading in kg/cu m (lb/1,000 gal) as chemical oxygen demand

SS = the suspended solids concentration in kg/cu m (lb/1,000 gal)

P = the phosphorus concentration in kg/cu m (lb/1,000 gal)

v = cost per cu m (1,000 gal) of liquid

w = cost per kg (lb) of BOD

x = cost per kg (lb) of COD

y = cost per kg (lb) of suspended solids

z = cost per kg (lb) of phosphorus

A second method was employed in which a different initial assumption was made.

Method 2 - Limited Budget Cost Distribution

Fundamental to the second method is the assumption that many budget cost items are independent of septage addition. These items were not included in the septage treatment cost determination.

TABLE 40. COST DISTRIBUTION - MEDFIELD - METHOD 1

	TOTAL ANNUAL COST, $	FLOW $/cu m	ORGANIC $/kg BOD	ORGANIC $/kg COD	Solids $/kg SS	Phosphorus $/kg P
Electrical	21,306	0.0185	0.0685	0.0345	0.0445	0.0450
Chemical	23,686	0.0057			0.0207	3.6184
Supplies	7,000	0.0051	0.0322	0.0143	0.0105	0.1477
Outside Services	2,650	0.0021	0.0134	0.0060	0.0044	0.0056
Clean Sewer	1,000	0.0024				
Travel	250	0.0002	0.0011	0.0005	0.0004	0.0053
Uniforms	650	0.0005	0.0033	0.0015	0.0011	0.0014
Telephone	588	0.0004	0.0027	0.0012	0.0009	0.0124
Heat	8,100	0.0029	0.0186	0.0083	0.0262	0.0855
Truck Fuel	115				0.0006	
Motor Repair	300				0.0015	
Consultant	4,000	0.0010	0.0123	0.0054	0.0119	0.0844
Personnel	38,376	0.0139	0.1469	0.0653	0.1051	0.4049
TOTAL	108,021	0.0527	0.2990	0.1370	0.2278	4.4106
		$/1,000 gal	$/lb BOD	$/lb COD	$/lb SS	$/lb P
TOTAL		0.1995	0.1356	0.0621	0.1033	2.0003

Items included in the estimate were increased in various ways. Electrical costs were increased by whole machine units, i.e., power for an additional aerator, thickener or vacuum filter was put in service for septage treatment. Chemical costs were increased as flow, suspended solids, and phosphorus were increased. The personnel costs expanded incrementally by the addition of an additional staff member. Small increases in fuel and motor repair accounts were included for completeness.

This approach is somewhat dependent upon economics of scale. It is very unlikely that a large plant having many operators would experience anything approaching the 33% manpower increase called for in the Medfield case, where allowance for an additional full-time staff member was made on a three-man base. Some discrepancy might also be expected in the electrical budget if operational flexibility were allowed. This analysis did not allow variation in equipment use overtime; a rather extreme position in any circumstances.

Method 3 - Incremented Effort Cost Evaluation

The same limited inventory of item cost categories was used as in Method 2. In Method 3 approximations were made of the change in effort induced by a 2% septage loading. These estimates were based upon the constant loading tests (Phase 2, Vol. 1). There was no constraint to assume whole-unit increments of costs. The indicated treatment costs are therefore more independent of the economics of scale.

Based upon oxygen demand data, aerator output was increased four hours each day at the 2% loading. For liquid stream treatment, labor costs were increased by four man-hours per day, based upon observation of the plant operation during the test period (Phase 2, Vol. 1 study).

COST COMPARISON

Table 41 shows a comparison of the unit costs of treating septage through the liquid and solids trains and gives the estimated total costs of each component. Table 42 is a comparison of costs derived by Methods 2 and 3 for both treatment trains.

Results of Method 1 indicate that a substantial cost savings can be realized by handling septage through the solids treatment train. Method 2 indicates little cost difference between liquid and solid train treatment. The results of Method 3, shown on Table 42, indicate some savings if alum is used as a coagulant. Aluminum conditioning of the septage appears to offer the lowest cost of the three chemical conditioning methods studied, with acid treatment second and

TABLE 41. COST DISTRIBUTION - METHOD I

		LIQUID STREAM TREATMENT			SOLIDS STREAM TREATMENT		
		STRENGTH		COMPONENT COST	STRENGTH		COMPONENT COST
Component	Unit Treatment Cost	mg/l	kg/cu m (lb/ 1000/gal)	$/cu m($/ 1000/gal)	mg/l	kg/cu m (lb/ 1000 gal)	$/cu m($/ 1000 gal)
COD							
Total	$0.1370/kg ($0.0621/lb)	14,564	14.6	2.00 (7.55)			
Super-natant	$0.1370/kg ($0.0621/lb)				1485	1.02* (8.52)	0.14 (0.53)
Filtrate	$0.1370/kg ($0.0621/lb)				2380	0.41* (3.40)	0.06 (0.21)
SS	$0.2278/kg ($0.1033/lb)	11,549	11.6 (96.3)	2.64 (9.95)	11,549	11.6 (96.3)	2.64 (9.95)
P	$4.4106/kg ($2.0003/lb)	127	0.13 (1.06)	0.57 (2.12)	0	0 (0)	0 (0)
FLOW	$0.0527/cu m ($0.1995/1000 gal)			0.05 (0.20)			0.05 (0.20)
Additional Chemical** (Including Polymer)							
Acid	$0.54/cu m ($2.04/1000 gal)						
Alum	$0.76/cu m ($2.87/1000 gal)						
Iron	$1.17/cu m ($4.42/1000 gal)						

TABLE 41. (continued)

TOTAL COST - METHOD I		
LIQUID STREAM	=	$5.26/cu m ($19.82/1000 gal)
SOLIDS STREAM		
Acid	=	$3.63/cu m
	=	($13.73/1000 gal)
Alum	=	$4.04/cu m
	=	($15.28/1000 gal)
Iron	=	$3.97/cu m
	=	($15.02/1000 gal)

*Based on supernatant volume equal to 68.8% of septage volume and filtrate volume equal to 17% of septage volume

**Both alum and ferric chloride remove phosphorus from liquid phase. Acid treatment leaves phosphorus in solution. Additional phosphorus removal is reflected in total acid treatment cost at same component cost as liquid stream treatment. Additional polymer estimated at $0.336/cu m ($1.27/1000 gal) raw septage treated.

TABLE 42. INCREMENTAL COSTS - METHODS 2 and 3
2% SEPTAGE ADDITION

Item	Liquid Stream Treatment		Solids Stream Treatment	
	Method 2	Method 3	Method 2	Method 3
Electrical				
$/cu m	0.24	0.08	0.01	0.01
($/1000 gal)	(0.91)	(0.31)	(0.04)	(0.04)
Chemicals				
Liquid Stream				
$/cu m	0.75	0.87		
($/1000 gal)	(2.89)	(3.29)		
Acid $/cu m			1.11	1.11
($/1000 gal)			(4.21)	(4.21)
Alum $/cu m			0.77	0.77
($/1000 gal)			(2.92)	(2.92)
Iron $/cu m			1.18	1.18
($/1000 gal)			(4.47)	(4.47)
Truck Fuel				
$/cu m	0.01	0.01	0.01	0.01
($/1000 gal)	(0.03)	(0.03)	(0.03)	(0.03)
Motor Repair				
$/cu m	0.02	0.02	0.02	0.02
($/1000 gal)	(0.07)	(0.07)	(0.07)	(0.07)
Personnel $/cu m	2.06	1.22	2.06	0.98
($/1000 gal)	(7.80)	(4.60)	(7.80)	(3.70)
TOTAL COSTS				
Liquid Stream				
$/cu m	3.08	2.20		
($/1000 gal)	(11.70)	(8.30)		
Acid Treatment				
$/cu m			3.21	2.13
($/1000 gal)			(12.15)	(8.05)
Alum Treatment				
$/cu m			2.87	1.79
($/1000 gal)			(10.81)	(6.76)
Iron Treatment				
$/cu m			3.28	2.20
($/1000 gal)			(12.41)	(8.31)

iron the most expensive. Acid treatment is more expensive at Medfield because of the need to remove phosphorus from the final effluent. If phosphorus removal were not required acid treatment would be the least expensive method.

Comparison of Capital Costs

Physical facilities would be needed for receiving, storing, feeding and treating septage if it is fed to either the liquid or solid streams at a plant. The cost of these facilities is site specific and would largely depend upon facilities already available at a particular plant. Flexibility to practice either mode of addition is desirable. Liquid stream addition would require utilization or expansion of aeration capacity and both modes of septage addition would require utilization or expansion of thickening and dewatering processes.

Land disposal costs for septage disposal is dependent upon site availability and cost, equipment cost and operation and operator salaries. In the Marlborough study (Vol. 1)[1], the added expense for a truck driver and disposal site operator was estimated at $0.11/cu m ($0.43/1000 gal) of septage. However, the truck costs were included in the Medfield costs shown on Tables 41 and 42.

REFERENCES

1. Segall, B.A., Ott, C.R., and Moeller, W.B., "Monitoring Septage Addition to Wastewater Treatment Plants, Volume I: Addition to the Liquid Stream," EPA-600/2-79-132, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1979.

2. Feige, W.A., Oppelt, E.T., and Kreissl, J.F., "An Alternative Septage Treatment Method: Lime Stabilization/Sand-Bed Dewatering," Environmental Protection Technology Series, EPA-600/2-75-036, September 1975.

3. Perrin, D.R., "Physical and Chemical Treatment of Septic Tank Sludge," M.S. Thesis, University of Vermont, February 1974.

4. Condren, A.J., "Pilot Scale Evaluations of Septage Treatment Alternatives," Environmental Protection Technology Series, EPA-600/2-78-164, September 1978.

5. Tilsworth, T. "The Characteristics and Ultimate Disposal of Waste Septic Tank Sludge," Report No. IWR-56, Institute of Water Resources, University of Alaska at Fairbanks, Alaska, November 1974.

6. Shaboo, A.A., "Selected Septage Conditioning Enhancing Settling and Dewatering,: M.S. Thesis, University of Lowell, December 1978.

7. Crowe, T.L., "Dewatering of Septage by Vacuum Filtration," M.S. Thesis, Clarkson College of Technology, September, 1974.

APPENDIX A

DETERMINATION OF OPTIMUM CHEMICAL DOSING

TABLE A - 1

TASK A - RAW SEPTAGE

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
RAW SEPTAGE										
COD, mg/l	19840	36560	27170	38790		49290		35270	60850	26620
Total Solids, mg/l	19870	42030	19530	38640	12760	31740	45000	21470	41600	17410
Total Volatile Solids, mg/l	16820	23650	15750	25010	9930	24790	26090	15900	29260	12730
pH	6.0	6.2		6.7	6.8		6.1	6.3	5.4	
Alkalinity, mg/l as $CaCO_3$		850		2480	617	1080	668	873		
CST	151	270	175	551	213	304	342	345	266	330
SETTLED RAW-SEPTAGE-SLUDGE										
COD, mg/l	35640		42020	64980		66540		30610		28140
Total Solids, mg/l	32260	88370	27970	73820	37390	47400	85700	54190	65720	45950
Total Volatile Solids, mg/l	28380	47010	22780	46520	29040	37000	46400	39440	44290	32260
Settling Cone, ml sludge/ ml total		445/905	565/905	500/955	300/930	620/930	450/920	370/950		
CST	123	319	167	440	216	234	203	224	225	187

TABLE A-2

TASK A - TREATED SEPTAGE BEFORE SETTLING

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Total Solids, mg/l @										
80 mg/l - Al(III) Dosage	16940		20550		12630					
100 mg/l - Al(III) Dosage	18900	46150	19460	39610	13080	33320	42970	23940	41270	19170
120 mg/l - Al(III) Dosage	18070	44470	20060	41410	13790	31670	45820	23260	41840	19100
140 mg/l - Al(III) Dosage	17910	46040	20750	41150	13500	33070	43600	22390	44740	19100
160 mg/l - Al(III) Dosage		43660	23670	41220	14200	31860	47830	23540	40920	19280
180 mg/l - Al(III) Dosage				41070	14550	32620	45440	23840	42400	19250
200 mg/l - Al(III) Dosage		45960	20860	41960	14220	35090	44670	23380	41030	20160
400 mg/l - Al(III) Dosage			22570	42120						
100 mg/l - Fe(III) Dosage	14610									
140 mg/l - Fe(III) Dosage	17400	42460	19690	38740	13050	30900	43520	22260	40440	18120
180 mg/l - Fe(III) Dosage	18240	45310	22400	38800	12490	31020	42970	21890	41710	18850
220 mg/l - Fe(III) Dosage	17440	44630	20880	37940	13190	31210	42930	21460	39090	18610
260 mg/l - Fe(III) Dosage	17310	41080	19990	37940	12750	31120	43020	22490	39350	18520
300 mg/l - Fe(III) Dosage		42410	19890	41230	12930	30740	43550	22430	39010	18720
340 mg/l - Fe(III) Dosage		42580	20520	40070	12310	30620	42170	22200	39740	18440
400 mg/l - Fe(III) Dosage									37170	
pH2	19780	46450	21530	45300	14710	30510	63420	29660	42410	29800
pH3	17230	45210	24230	40660	13270	30150	50490	25920	40450	24920
Total Volatile Solids, mg/l, @										
80 mg/l - Al(III) Dosage	13970		15580		9390					
100 mg/l - Al(III) Dosage	15600	29600	14660	25520	9930	25560	24110	16670	28110	13230
120 mg/l - Al(III) Dosage	14780	23260	15440	26780	9600	23840	26340	16190	28310	13100
140 mg/l - Al(III) Dosage	14490	23760	15720	26530	10160	25110	24440	15780	30560	13130
160 mg/l - Al(III) Dosage		22910	18690	25630	9790	24100	27840	16200	27720	13180
180 mg/l - Al(III) Dosage				25360	10340	24690	25860	16560	28710	12950
200 mg/l - Al(III) Dosage		23330	15530	25170	10490	26860	25000	16140	27570	13610
400 mg/l - Al(III) Dosage			16230	24710	10020					
100 mg/l - Fe(III) Dosage	12530									
140 mg/l - Fe(III) Dosage	14950	23270	15650	25030	10040	23770	24860	16180	28210	12920
180 mg/l - Fe(III) Dosage	15390	23900	16890	24300	9450	23740	24240	15740	28800	13530
220 mg/l - Fe(III) Dosage	14730	23390	15790	24820	10060	24020	24390	15540	26930	13330
260 mg/l - Fe(III) Dosage	14560	22890	15630	24290	9580		24330	16400	27220	13180
300 mg/l - Fe(III) Dosage		22320	15420	25890	9850	23380	24500	16180	26860	13460
340 mg/l - Fe(III) Dosage		22130	15450	23820	9320	23710	23670	16210	27460	13120
400 mg/l - Fe(III) Dosage									25570	
pH2	16180	25910	16800	28070	11160	22770	43680	18870	29240	13660
pH3	16820	24550	16360	25440	10190	22830	31740	18340	27650	14690

TABLE A-2 - (Continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
pH @										
80 mg/l - Al(III) Dosage	5.3									
100 mg/l - Al(III) Dosage	5.5	5.7						5.2	5.1	
120 mg/l - Al(III) Dosage	5.2	5.7						5.0	5.0	
140 mg/l - Al(III) Dosage	5.0	5.6						4.9	4.9	
160 mg/l - Al(III) Dosage		5.6						4.8	4.8	
180 mg/l - Al(III) Dosage								4.6	4.7	
200 mg/l - Al(III) Dosage		5.4						4.5	4.5	
100 mg/l - Fe(III) Dosage	5.4									
140 mg/l - Fe(III) Dosage	5.3	5.9						5.3	5.2	
180 mg/l - Fe(III) Dosage	5.3	5.9						5.2	5.2	
220 mg/l - Fe(III) Dosage	5.2	5.8						5.1	5.1	
260 mg/l - Fe(III) Dosage	5.1	5.7						5.0	5.2	
300 mg/l - Fe(III) Dosage		5.7						4.9	5.1	
340 mg/l - Fe(III) Dosage		5.6						4.8	4.9	
pH2	2.1	2.3						2.2	2.4	
pH3	4.5	4.0						3.6	3.9	
CST @										
80 mg/l - Al(III) Dosage	42		83		14					
100 mg/l - Al(III) Dosage	26	78	47	230	11	82	60	33	97	86
120 mg/l - Al(III) Dosage	21	67	31	191	12	68	35	25	68	49
140 mg/l - Al(III) Dosage	14	50	24	201	11	52	25	25	64	26
160 mg/l - Al(III) Dosage		52	25	178	12	41	25	24	44	27
180 mg/l - Al(III) Dosage				166	15	40	20	18	37	22
200 mg/l - Al(III) Dosage		40	26	173	9	41	20	19	40	20
400 mg/l - Al(III) Dosage			29	58	12					
800 mg/l - Al(III) Dosage				36						
100 mg/l - Fe(III) Dosage	89									
140 mg/l - Fe(III) Dosage	48	123	62	258	32	202	114	145	128	255
180 mg/l - Fe(III) Dosage	31	90	30	297	14	135	71	77	135	231
220 mg/l - Fe(III) Dosage	21	72	37	260	9	121	30	38	100	141
260 mg/l - Fe(III) Dosage	15	55	21	116	8	69	23	29	85	103
300 mg/l - Fe(III) Dosage		42	16	65	7	62	18	18	61	57
340 mg/l - Fe(III) Dosage		37	34	64	7	128	19	26	41	21
400 mg/l - Fe(III) Dosage							-		18	
pH2	57	89	53	308	67	50	34	71	55	32
pH3	82	94	58	185	38	114	30	55	77	37

TABLE A-3

TASK A - SEPTAGE SLUDGE AFTER SETTLING

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
COD, mg/l, @										
80 mg/l - Al(III) Dosage	37050		48010							
100 mg/l - Al(III) Dosage	31910		50840							
120 mg/l - Al(III) Dosage	40770		48300							
140 mg/l - Al(III) Dosage	36730		48390							
160 mg/l - Al(III) Dosage			45920							
200 mg/l - Al(III) Dosage			48460							
400 mg/l - Al(III) Dosage			46720							
100 mg/l - Fe(III) Dosage	33460									
140 mg/l - Fe(III) Dosage	33620		51510							
180 mg/l - Fe(III) Dosage	30820		52650							
220 mg/l - Fe(III) Dosage	35180		49220							
260 mg/l - Fe(III) Dosage	35800		48030							
300 mg/l - Fe(III) Dosage			49730							
340 mg/l - Fe(III) Dosage			50270							
pH2	34240		43450							
pH3	36420		44140							
Total Solids, mg/l @										
80 mg/l - Al(III) Dosage	33690		31370		27970					
100 mg/l - Al(III) Dosage	33080	87030	32440	73200	28570	43600	74440	45900	56730	39090
120 mg/l - Al(III) Dosage	32010	84090	32190	75490	29410	43600	76930	44690	59890	38050
140 mg/l - Al(III) Dosage	33060	84290	32100	67200	28080	45000	78630	46390	61660	38490
160 mg/l - Al(III) Dosage		84040	32200	72630	29570	47800	78380	46300	59930	38980
180 mg/l - Al(III) Dosage				74230	29470	47000	87280	46410	63400	39180
200 mg/l - Al(III) Dosage		84020	33140	72740	29710	48800	78770	46890	61900	38340
400 mg/l - Al(III) Dosage			34360	72890						
800 mg/l - Al(III) Dosage				66530						
100 mg/l - Fe(III) Dosage	29320									
140 mg/l - Fe(III) Dosage	36300	108850	35160	78160	29750	44000	82120	48000	64630	44710
180 mg/l - Fe(III) Dosage	34720	88740	38220	76980	30190	43200	78880	47510	59650	43750
220 mg/l - Fe(III) Dosage	37150	95290	32680	75790		45000	77660	48370	59500	42370
260 mg/l - Fe(III) Dosage	31740	92530	33230	73390	31130	46600	84160	47860	65060	39830
300 mg/l - Fe(III) Dosage		91920	32080	72800	30700	43000	80660	48460	62000	41200
340 mg/l - Fe(III) Dosage		89980	37370	72470	32790	43000	82260	49270	65560	40160
400 mg/l - Fe(III) Dosage									59870	
pH2	30670	95030	30420	70780	30270	45200	84760	53280	64280	49360
pH3	26670	89270	31290	71160	30050	39400	75230	42640	59810	39770

(continued)

TABLE A-3 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Total Volatile Solids, mg/l, @										
80 mg/l - Al(III) Dosage	28480		24260		21120					
100 mg/l - Al(III) Dosage	27670	45320	25080	44680	21470	33600	40690	32010	37590	27610
120 mg/l - Al(III) Dosage	26770	42990	24960	46490	22160	33800	43030	30970	39830	26630
140 mg/l - Al(III) Dosage	27490	42990	24640	41850	20730	34400	44010	31910	41200	26950
160 mg/l - Al(III) Dosage		42310	25010	45390	21780	37200	44190	32020	39700	27230
180 mg/l - Al(III) Dosage				45600	21820	36400	53880	31570	42280	27470
200 mg/l - Al(III) Dosage		41860	25160	44990	21800	37400	44850	32170	40990	26430
400 mg/l - Al(III) Dosage			25010	45450						
100 mg/l - Fe(III) Dosage	25470									
140 mg/l - Fe(III) Dosage	31710	59770	27440	47520	22790	34400	46530	33530	43110	31620
180 mg/l - Fe(III) Dosage	29560	46160	28730	48300	22780	33400	43630	33130	39320	31300
220 mg/l - Fe(III) Dosage	30560	49360	24990	47610		34800	43520	33700	39180	30260
260 mg/l - Fe(III) Dosage	27090	50860	25690	45630	23660	36400	48230	34020	42800	28510
300 mg/l - Fe(III) Dosage		46060	24870	45120	23490	33600	45620	33610	40830	29160
340 mg/l - Fe(III) Dosage		46450	27440	45410	25000	32800	46980	35110	43820	28650
400 mg/l - Fe(III) Dosage									41370	
pH2	25450	55130	24070	45990	23780	35800	55590	37190	45890	28750
pH3	23380	47770	22190	26300	23440	31000	46380	30750	41560	26510
Settling Cone, ml sludge/ ml total										
80 mg/l - Al(III) Dosage			600/940		450/940					
100 mg/l - Al(III) Dosage		495/990	565/945	550/950	440/960	700/950	535/935	490/950		
120 mg/l - Al(III) Dosage		480/930	600/950	555/945	440/970	690/940	530/950	500/970		
140 mg/l - Al(III) Dosage		505/945	600/950	580/940	460/980	680/940	530/940	480/960		
160 mg/l - Al(III) Dosage		540/980	635/945	570/950	450/975	680/960	530/950	490/970		
180 mg/l - Al(III) Dosage				560/960	455/975	680/955	530/950	490/960		
200 mg/l - Al(III) Dosage		525/965	600/950	560/950	450/980	670/955	535/965	490/970		
400 mg/l - Al(III) Dosage			620/1010	600/900						
800 mg/l - Al(III) Dosage				630/970						
140 mg/l - Fe(III) Dosage		450/950	550/950	500/950	410/970	690/950	505/955	450/960		
180 mg/l - Fe(III) Dosage		460/935	540/950	510/950	400/970	690/960	510/960	460/980		
220 mg/l - Fe(III) Dosage		450/940	580/960	520/950	410/970	690/980	510/980	450/980		
260 mg/l - Fe(III) Dosage		495/985	600/970	550/980	410/990	680/975	500/950	440/950		
300 mg/l - Fe(III) Dosage		495/970	580/980	550/980	420/1000	680/980	500/980	450/990		
340 mg/l - Fe(III) Dosage		500/995	570/980	550/990	395/1000	650/930	530/1010	460/970		
pH2		460/925	670/930	570/930	395/915	750/950	580/1030	430/1010		
pH3		450/910	660/920	500/900	390/930	780/920	565/975	500/950		

(continued)

TABLE A-3 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
CST, @										
80 mg/l - Al(III) Dosage	78		68		40					
100 mg/l - Al(III) Dosage	53	196	69	221	26	103	70	92	141	86
120 mg/l - Al(III) Dosage	50	144	42	217	22	99	55	57	110	63
140 mg/l - Al(III) Dosage	23	121	32	192	19	84	44	47	116	40
160 mg/l - Al(III) Dosage		116	32	199	16	81	40	40	118	35
180 mg/l - Al(III) Dosage				207	15	63	33	37	88	26
200 mg/l - Al(III) Dosage		88	26	167	20	55	28	30	87	25
400 mg/l - Al(III) Dosage			24	102						
800 mg/l - Al(III) Dosage				35						
100 mg/l - Fe(III) Dosage	113									
140 mg/l - Fe(III) Dosage	61	180	88	287	135	166	136	180	159	118
180 mg/l - Fe(III) Dosage	51	187	69	221	123	139	99	163	163	100
220 mg/l - Fe(III) Dosage	42	148	57	186	113	145	74	178	173	82
260 mg/l - Fe(III) Dosage	35	135	37	160	104	112	53	180	142	68
300 mg/l - Fe(III) Dosage		106	30	133	81	87	51	110	135	66
340 mg/l - Fe(III) Dosage		102	50	110	68	292	49	122	139	41
pH2	39	105	47	109	92	50	32	76	52	34
pH3	73	137	30	239	124	133	28	84	80	44

TABLE A-4

TASK A - SUPERNATANT AFTER SETTLING

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
COD mg/1, @										
0 mg/1					2120	5250	6800	6890		
80 mg/1 - Al(III) Dosage	2800		3570		550					
100 mg/1 - Al(III) Dosage	2370	3280	3410	5550	550	980	1210	1890	3050	2640
120 mg/1 - Al(III) Dosage	2180	2620	2980	4490	200	740	980	1720	2840	2280
140 mg/1 - Al(III) Dosage	2300	2300	2820	3790	710	590	1090	1540	2500	2260
160 mg/1 - Al(III) Dosage		2340	2780	3710	550	750	1060	1670	2520	2000
180 mg/1 - Al(III) Dosage				3630	510	590	980	1470	2600	1900
200 mg/1 - Al(III) Dosage		2300	2710	3360	470	550	940	1570	2500	1960
400 mg/1 - Al(III) Dosage			2710	2620						
100 mg/1 - Fe(III) Dosage	2950									
140 mg/1 - Fe(III) Dosage	3990	4100	4240	7230	550	2350	2230	2770		4300
180 mg/1 - Fe(III) Dosage	2020	3320	3880	6170	430	1800	1560	2160		3590
220 mg/1 - Fe(III) Dosage	1980	3160	3880	5040	630	1370	1290	2040		3040
260 mg/1 - Fe(III) Dosage	2130	2380	3260	3590	430	940	1130	1740	2800	2640
300 mg/1 - Fe(III) Dosage		2340	2940	3240	540	900	980	1590	2960	2570
340 mg/1 - Fe(III) Dosage		2110	3330	2930	540		900	1620	2790	2053
pH2	2480	3670	3650	3200	960	1180	1250	2120	2560	2015
pH3	3020	3460	3410	7310	650	1100	1172	2010	2730	2380
Total Solids, mg/1, @										
0 mg/1					1220	3130	3960	3870	3400	
80 mg/1 - Al(III) Dosage	1910		2410		960					
100 mg/1 - Al(III) Dosage	1960	2550	2480	3800	1100	2080	1680	1780	2490	1920
120 mg/1 - Al(III) Dosage	1880	2580	2440	3710	1520	2080	1840	1860	2790	2010
140 mg/1 - Al(III) Dosage	2160	2600	2470	3630	1750	2360	1950	1980	2800	2130
160 mg/1 - Al(III) Dosage		2720	2630	3640	1920	2530	1980	2080	2860	2140
180 mg/1 - Al(III) Dosage				3950	2100	2590	2360	2170	3020	2460
200 mg/1 - Al(III) Dosage		3010	2780	4130	2250	2690	2450	2370	3110	2570
400 mg/1 - Al(III) Dosage			4820	5460						
800 mg/1 - Al(III) Dosage				8400						
100 mg/1 - Fe(III) Dosage	2120									
140 mg/1 - Fe(III) Dosage	1690	2710	2460	4080	880	2110	1800	1850	2460	2610
180 mg/1 - Fe(III) Dosage	1690	2420	2320	3760	790	2070	1460	1690	2550	2310
220 mg/1 - Fe(III) Dosage	1820	2460	2300	3510	910	1990	1380	1550	2560	2160
260 mg/1 - Fe(III) Dosage	1770	2230	2200	2930	980	1900	1310	1600	2490	2180
300 mg/1 - Fe(III) Dosage		2110	2350	3160	1050	2160	2080	1780	2280	2130
340		2280	2140	3130	1220	3610	1830	1990	2650	2000
pH2	5450	9650	5890	8090	3340	5460	32170	9040	5120	17050
pH3	3790	5660	7480	8490	1730	3780	14080	4840	3290	8140

(continued)

TABLE A-4 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Total Volatile Solids, mg/l @										
0 mg/l					860	2600	3180	3040	2570	
80 mg/l - Al(III) Dosage	750		870		300					
100 mg/l - Al(III) Dosage	500	1070	1000	2020	280	860	620	630	780	970
120 mg/l - Al(III) Dosage	510	840	760	1680	350	690	480	500	1020	650
140 mg/l - Al(III) Dosage	510	660	800	1550	400	840	410	500	870	630
160 mg/l - Al(III) Dosage		800	770	1390	470	850	200	590	870	480
180 mg/l - Al(III) Dosage				1470	610	950	450	600	780	690
200 mg/l - Al(III) Dosage		650	680	1420	560	860	490	640	710	650
400 mg/l - Al(III) Dosage			1610	1130						
800 mg/l - Al(III) Dosage				1640						
100 mg/l - Fe(III) Dosage	1400									
140 mg/l - Fe(III) Dosage	960	1740	1440	2930	440	1440	1250	1200	1410	1870
180 mg/l - Fe(III) Dosage	980	1420	1250	2500	330	1300	720	1010	1190	1530
220 mg/l - Fe(III) Dosage	850	1440	1090	2280	380	1140	500	940	1310	1400
260 mg/l - Fe(III) Dosage	750	1230	1140	1390	330	960	320	800	1090	1230
300 mg/l - Fe(III) Dosage		900	1360	1870	530	1150	1070	920	980	1120
340 mg/l - Fe(III) Dosage		1160	1320	1370	380	3030	490	1020	1320	940
400 mg/l - Fe(III) Dosage									860	
pH2	2490	4850	3340	3170	1700	2060	27780	2550	1440	2550
pH3	1850	2300	1780	3680	660	1710	9770	1360	980	1800
pH @										
80 mg/l - Al(III) Dosage	5.4									
100 mg/l - Al(III) Dosage	5.3			7.0		5.8				
120 mg/l - Al(III) Dosage	5.2			7.0		5.5				
140 mg/l - Al(III) Dosage	5.1			7.1		5.2				
160 mg/l - Al(III) Dosage				7.0		4.9				
180 mg/l - Al(III) Dosage				7.0		4.7				
200 mg/l - Al(III) Dosage				7.0		4.6				
400 mg/l - Al(III) Dosage				6.6						
800 mg/l - Al(III) Dosage				4.4						
100 mg/l - Fe(III) Dosage	5.5									
140 mg/l - Fe(III) Dosage	5.4			6.7		5.9				
180 mg/l - Fe(III) Dosage	5.2			6.7		5.8				
220 mg/l - Fe(III) Dosage	5.2			6.6		5.6				
260 mg/l - Fe(III) Dosage	5.2			6.8		5.6				
300 mg/l - Fe(III) Dosage				6.6		5.5				
340 mg/l - Fe(III) Dosage				6.6		5.4				
pH2	2.1			2.2		0.9				
pH3	4.6			4.9		1.3				

APPENDIX B

TASK B - VACUUM FILTRATION OF CONDITIONED SEPTAGE SLUDGE

TABLE B-1

TASK B - CAKE CHARACTERISTICS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l	140	160	140	400	100	160	180	180	180	180
Sludge CST	40			167	33	107	49	45	89	26
Filtration Pressure, kPa - 103 (lb/sq in)	15	15	15	15	15	15	15	15	15	15
Cake Thickness, in										
$*t_f$ = 1 min	.15	NM**	.3	.1	.1	.12	.12	.08	.04	.04
2 min	.15	NM	.3	.1	.1	.12	.12	.08	.04	.04
4 min	.15	.025	.3	.1	.1	.04	.12	.08	.04	.04
Dry Cake Weight, g										
t_f = 1 min	7.52	3.13	6.31	3.92	2.02	3.30	7.36	4.21	2.60	2.74
2 min	7.03	2.62	6.20	4.46	2.42	2.54	6.03	3.41	2.60	3.91
4 min	9.57	3.08	8.64	4.28	2.55	2.20	6.13	3.91	2.86	4.61
Cake Total Solids, %										
t_f = 1 min	27.4	28.1	27.3	24.6	20.9	17.5	25.6	20.6	28.3	24.8
2 min	28.0	30.8	28.5	29.5	23.8	23.0	29.8	24.2	31.8	25.3
4 min	30.6	33.9	29.2	32.1	25.3	20.1	33.0	27.8	35.2	27.6
Cake Volatile Solids, % of TS										
t_f = 1 min	83.9	40.3	86.9	70.8	78.2	79.7	59.7	73.2	69.2	73.7
2 min	85.1	49.8	80.5	69.0	79.3	79.1	60.2	76.5	70.8	73.2
4 min	83.3	56.2	80.6	69.6	79.6	79.1	60.4	75.7	70.6	70.7
Cake Yield, (lb/sq ft-hr)										
t_f = 1 min	1.90	1.03	2.09	1.30	.67	1.09	2.43	1.39	.86	.91
2 min	.92	.43	1.03	.74	.40	.42	1.00	.56	.43	.65
4 min	.46	.25	.71	.35	.21	.18	.51	.32	.24	.38
Filtration Pressure, kPa - 52 (lb/sq in)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, in										
t_f = 1 min	.15	NM	.2	.05	.1	.04	.08	.08	.04	.04
2 min	.20	NM	.2	.05	.1	.04	.08	.08	.04	.04
4 min	.15	NM	.2	.05	.1	.04	.08	.08	.04	.04

$*t_f$ = form time

**NM = Not measurable - thin

(continued)

TABLE B-1 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	5.59	1.56	4.47	2.73	2.99	1.72	4.02	2.59	1.40	2.49
2 min	6.87	2.36	5.82	3.09	2.79	2.03	3.58	3.57	2.05	2.60
4 min	5.37	2.25	5.74	3.20	3.02	2.01	4.71	4.32	2.00	3.58
Cake Total Solids, %										
t_f = 1 min	22.0	25.9	23.5	21.0	17.9	18.9	26.6	18.9	25.6	20.1
2 min	23.5	29.8	20.9	24.7	20.1	21.7	27.4	22.1	27.0	22.8
4 min	24.0	30.5	26.6	25.4	22.3	22.3	29.8	24.4	33.3	24.3
Cake Volatile Solids, % of TS										
t_f = 1 min	83.0	48.5	81.4	71.0	79.6	79.1	59.0	77.2	70.7	73.9
2 min	82.4	48.4	73.1	70.6	79.2	80.3	58.7	76.5	72.2	75.0
4 min	82.7	47.1	74.0	72.3	77.8	80.6	58.4	73.8	73.5	75.1
Cake Yield, lb/sq ft-hr										
t_f = 1 min	1.23	0.52	1.48	.90	.99	.57	1.33	.86	.46	.82
2 min	1.10	0.39	.96	.51	.46	.34	.59	.59	.34	.43
4 min	.39	0.19	.47	.26	.25	.17	.39	.36	.17	.30

TABLE B-2

TASK B - CAKE CHARACTERISTICS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l	260	340	300	300	220	300	300	300	400	340
Sludge CST	63			353	121	138	74	143	140	43
Filtration Pressure, kPa-103 (lb/sq in)	15	15	15	15	15	15	15	15	15	15
Cake Thickness, in										
t_f = 1 min	.15	NM	.1	.1	.1	.04	.08	NM	.04	.04
2 min	.15	NM	.1	.1	.1	.04	.12	NM	.04	.08
4 min	.15	.025	.1	.1	.1	.08	.12	NM	.04	NM
Dry Cake Weight, g										
t_f = 1 min	5.89	3.47	5.79	2.71	2.45	2.66	6.45	2.48	2.90	1.57
2 min	6.57	3.14	5.31	2.48	2.17	1.96	4.92	1.65	1.98	2.07
4 min	5.68	3.51	6.73	3.39	2.15	2.01	5.38	1.93	2.33	1.56
Cake Total Solids, %										
t_f = 1 min	23.4	25.8	28.7	24.7	21.8	21.3	25.9	23.7	26.1	25.4
2 min	26.3	28.5	29.9	28.3	22.9	24.0	31.5	24.0	33.0	27.3
4 min	26.9	33.1	31.9	31.3	24.7	26.2	36.4	27.3	36.4	28.1
Cake Volatile Solids, % of TS										
t_f = 1 min	85.3	56.2	85.5	73.6	80.4	79.7	58.3	71.0	70.7	73.9
2 min	85.7	52.6	84.9	67.4	80.7	78.6	60.0	77.0	71.7	73.0
4 min	86.1	47.5	83.2	69.8	80.0	79.1	59.3	76.7	70.8	73.1
Cake Yield, lb/sq ft-hr										
t_f = 1 min	1.95	1.15	1.91	.90	.81	.88	2.13	.82	.96	.52
2 min	1.09	0.52	.88	.41	.36	.32	.81	.27	.33	.34
4 min	.47	0.29	.56	.28	.18	.17	.44	.16	.19	.13
Filtration Pressure, kPa -52 (lb/sq in)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, in										
t_f = 1 min	.10	NM	.1	.1	.05	.04	.08	NM	.08	NM
2 min	.10	NM	.2	.1	.1	NM	.08	NM	.04	NM
4 min	.15	NM	.1	.1	.1	NM	.08	NM	.04	NM

(continued)

TABLE B-2 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	4.76	2.11	4.92	2.30	1.85	1.71	4.14	1.70	2.41	1.31
2 min	5.08	2.73	7.95	3.04	1.95	1.47	3.60	1.69	2.45	1.07
4 min	4.23	2.38	4.14	2.93	2.29	1.66	5.50	1.75	2.08	1.34
Cake Total Solids, %										
t_f = 1 min	20.1	27.1	26.2	18.6	17.7	19.2	27.8	21.6	23.5	20.9
2 min	21.6	28.9	26.2	25.9	20.2	20.9	29.9	22.5	26.5	23.2
4 min	21.2	31.1	27.1	25.1	21.3	20.4	32.0	23.5	30.5	22.4
Cake Volatile Solids,% of TS										
t_f = 1 min	87.2	40.3	67.8	71.6	81.6	79.5	58.0	76.5	71.0	74.8
2 min	84.3	47.9	72.5	70.3	81.6	79.6	58.1	73.4	72.7	75.7
4 min	84.5	59.3	68.6	71.5	80.6	79.5	62.4	74.9	72.1	75.4
Cake Yield, lb/sq ft-hr										
t_f = 1 min	1.58	0.70	1.63	.76	.61	.57	1.37	.56	.80	.43
2 min	0.84	0.45	1.31	.50	.32	.24	.60	.28	.41	.18
4 min	0.35	0.20	0.34	.24	.19	.14	.45	.14	.17	.11

TABLE B-3

TASK B - CAKE CHARACTERISTICS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	3	3	2	2
Sludge CST	74			148	138	60	55	143	45	43
Filtration Pressure, kPa -103 (lb/sq in)	15	15	15	15	15	15	15	15	15	15
Cake Thickness, in										
t_f = 1 min	.15	NM	.3	.1	.1	.04	.08	NM	.04	NM
2 min	.15	NM	.3	.05	.1	NM	.08	NM	.04	NM
4 min	.20	NM	.2	.1	.1	NM	.12	NM	.04	NM
Dry Cake Weight, g										
t_f = 1 min	7.52	1.70	6.45	2.69	3.26	2.17	4.53	1.50	2.72	.86
2 min	7.03	1.54	8.13	1.98	2.58	1.30	3.09	1.88	2.21	1.33
4 min	9.57	1.71	10.20	3.44	2.71	1.16	4.38	1.84	2.66	1.29
Cake Total Solids, %										
t_f = 1 min	27.4	32.6	23.9	30.3	19.3	24.0	29.7	25.4	32.1	28.9
2 min	28.0	35.7	27.3	30.4	24.8	26.0	31.7	27.3	36.1	31.0
4 min	30.6	36.1	32.2	34.2	28.0	26.7	34.6	27.7	36.7	30.3
Cake Volatile Solids, % of TS										
t_f = 1 min	83.9	50.8	88.4	68.3	84.7	84.8	62.3	80.7	74.3	80.2
2 min	85.1	52.0	74.5	69.8	86.0	83.1	65.4	79.8	73.3	82.0
4 min	83.3	51.8	75.9	73.0	85.2	85.3	63.5	81.0	75.9	82.2
Cake Yield, lb/sq ft-hr										
t_f = 1 min	2.49	0.56	2.13	.89	1.08	.72	1.50	.50	.90	.28
2 min	1.16	0.25	1.34	.33	.43	.21	.51	.31	.37	.22
4 min	.79	0.14	0.84	.28	.22	.10	.36	.15	.22	.11
Filtration Pressure, kPa -52 (lb/sq in)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, in										
t_f = 1 min	.15	NM	.1	.05	.1	NM	.08	NM	.04	NM
2 min	.15	NM	.1	.05	.1	NM	.04	NM	.08	NM
4 min	.15	NM	.05	.1	.1	NM	.04	NM	.08	NM

(continued)

TABLE B-3 (Continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	5.59	1.71	2.89	1.47	2.30	1.42	3.46	1.51	3.45	.94
2 min	6.87	1.58	5.05	2.03	2.19	1.19	2.82	1.67	5.41	1.28
4 min	5.37	1.83	2.12	2.45	2.39	.94	3.20	1.62	6.84	1.37
Cake Total Solids, %										
t_f = 1 min	22.0	28.6	27.9	24.1	18.4	20.9	28.0	19.1	25.3	24.6
2 min	23.5	32.4	29.3	25.6	19.6	22.2	28.8	22.9	26.0	26.8
4 min	24.0	31.9	28.2	25.4	22.3	21.8	30.4	23.8	28.6	27.9
Cake Volatile Solids,% of TS										
t_f = 1 min	83.0	52.8	42.1	71.6	84.8	83.1	61.3	83.4	68.7	79.8
2 min	82.4	52.8	74.1	71.1	85.4	82.4	61.4	85.0	70.4	80.5
4 min	82.7	55.7	75.3	74.0	83.7	83.0	61.6	84.6	68.4	76.6
Cake Yield, lb/sq ft-hr										
t_f = 1 min	1.85	0.57	.96	.49	.76	.47	1.14	.50	1.14	.31
2 min	1.14	0.26	.83	.34	.36	.20	.47	.28	.89	.21
4 min	.44	0.15	.18	.20	.20	.08	.26	.13	.57	.11

TABLE B-4

TASK B - FILTRATE, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage	140	160	140	400	100	160	180	180	180	180
Filtration Pressure, kPa -103 (lb/sq in)	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	4190	10230		8620	4250	6590	3420	4590	12180	5810
2 min	3590	10560		8890	4490	8000	4380	6190	12260	5840
4 min	3640	10800		7970	4670	8110	4720	5500	11770	5060
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2110	5690		5220	2510	4010	1160	2560	7490	2950
2 min	1620	5400		5370	2590	4790	1590	3500	7370	2840
4 min	1640	5750		4710	2680	5000	1930	2920	7330	2300
Filtrate COD, mg/l										
t_f = 1 min	5210	12680	9810	11940	5100	8610	2890	5980	16740	7360
2 min	4280	14170	7700	12790	4900	11940	3360	7370	17520	6820
4 min	4280	13780	6790	11320	4940	10780	3750	6580	19460	6280
Filtrate pH										
t_f = 1 min		5.5	5.2	7.7	5.9		5.4	5.0	4.7	5.4
2 min		5.4	5.1	7.5	5.9		5.3	4.8	4.8	5.3
4 min		5.5	5.0	7.4	6.0		5.2	4.8	4.8	5.3
Filtration Pressure, kPa -52 (lb/sq in)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	3740	18400		5820	3150	10530	5880	7200	19320	7390
2 min	3090	14310		5260	3520	9030	6080	6520	16370	6920
4 min	3420	10900		8390	3770	8310	5350	6200	11500	5990
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1760	9760		3680	1550	6930	2790	4480	11690	3960
2 min	1280	7760		3280	1920	5790	2740	3750	10010	3660
4 min	1430	5740		5270	2090	5420	2170	3510	6880	3000

(continued)

TABLE B-4 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Filtrate COD, mg/l										
t_f = 1 min	4400	20870	9590	18060	3500	14110	5230	9250	29300	8610
2 min	3500	17950	8600	15660	3970	13330	5780	7740	19930	7830
4 min	3430	15350	9740	17440	3810	12330	4530	7670	17290	6980
Filtrate pH										
t_f = 1 min		5.4	5.0	7.6	5.8		5.3	4.8	4.7	5.3
2 min		5.4	5.1	7.3	5.8		5.4	4.8	4.7	5.5
4 min		5.4	5.0	7.5	6.0		5.4	4.8	4.8	5.3

TABLE B-5

TASK B - FILTRATE, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l	260	340	300	300	220	300	300	300	400	340
Filtration Pressure, lb/sq in	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	4540	8900		4180	3720	9350	3960	7050	4440	4140
2 min	7740	8490		4820	5020	9140	4800	10310	13640	4980
4 min	3640	10670		8520	5330	8260	5500	9950	13290	5620
Filtrate Volatile Solids, mg/l										
t_f = 1 min	3140	5380		3020	2510	6790	2070	5070	2760	2450
2 min	5200	5040		3670	3550	6350	2880	7400	9320	3160
4 min	2220	6510		6130	3590	5800	3070	7260	9050	3530
Filtrate COD, mg/l										
t_f = 1 min	7980	12760	10490	14730	4400	12790	4450	15110	5970	5350
2 min	5600	10000	11240	17210	6190	11700	5080	15580	18450	6900
4 min	5210	12990	8220	17990	7160	12010	6330	15560	17600	7600
Filtrate pH										
t_f = 1 min		5.3	5.8	7.3	5.8		6.3	5.6	5.0	6.0
2 min		5.3	5.7	7.4	5.8		6.0	5.6	4.9	5.7
4 min		5.3	5.6	7.3	5.7		5.8	5.7	4.9	5.7
Filtration Pressure, lb/sq in	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	4090	19120		4830	7220	11260	6440	12940	17610	8435
2 min	3220	14330		8780	7240	9730	7780	11440	15070	7215
4 min	3670	12120		6100	6460	7960	6030	11070	11380	6423
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2780	10920		3460	4950	7780	3600	9370	11520	5400
2 min	1900	8770		6400	4960	7190	4430	8030	9640	4790
4 min	2370	6840		4380	4400	5890	3430	7840	7490	4140
Filtrate COD, mg/l										
t_f = 1 min	5880	22050	10720	18220	9380	15190	7030	18500	27290	11780
2 min	3770	18110	11090	18060	9420	15120	8910	18120	20000	9850
4 min	4820	16060	12230	16360	8290	11390	6410	16470	16670	8990
Filtrate pH										
t_f = 1 min		5.2	5.7	7.4	5.7		5.9	5.5	4.9	5.7
2 min		5.3	5.6	7.4	5.7		5.9	5.5	4.9	5.7
4 min		5.2	5.6	7.3	5.7		5.9	5.4	4.9	5.7

TABLE B-6

TASK B - FILTRATE, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	3	3	2	2
Filtration Pressure, kPa-103 (lb/sq in)	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	8000	25880		16140	5590	10270	6220	11200	14220	9890
2 min	7810	22560		13710	6620	10390	6880	11540	12890	10100
4 min	9650	21890		17030	6750	9970	5850	11100	12880	10060
Filtrate Volatile Solids, mg/l										
t_f = 1 min	4730	15290		6850	3590	5510	2480	7790	7710	6030
2 min	4490	13230		5470	4480	5750	3190	8100	7270	6380
4 min	6180	12780		6530	4580	5310	2430	7810	7090	6460
Filtrate COD, mg/l										
t_f = 1 min	7000	21260	12080	14340	6890	10930	5940	16840	16360	11160
2 min	6500	23620	11250	13800	8290	10620	6330	16840	15120	10700
4 min	6110	18350	9810	14730	8560	9850	4840	15790	14110	10230
Filtrate pH										
t_f = 1 min		1.6	4.2	5.6	5.2		4.5	4.5	3.0	2.7
2 min		1.5	4.2	4.4	5.0		4.3	4.5	2.7	2.3
4 min		1.5	4.2	4.1	5.0		4.3	4.5	2.6	2.3
Filtration Pressure, kPa - 52 (lb/sq in)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	7600	23360		7830	8370	9660	9330	13350	17680	11120
2 min	7260	24700		9030	8500	10080	8270	12160	11680	10160
4 min	7430	20660		8990	7870	9310	6590	11350	10390	9700
Filtrate Volatile Solids, mg/l										
t_f = 1 min	4300	13100		3340	5730	5290	4480	9440	10450	7330
2 min	4030	14450		3890	5990	5490	3990	9220	5880	6540
4 min	3990	12460		3600	5490	4960	3050	8380	4860	6080
Filtrate COD, mg/l										
t_f = 1 min	6190	24020	14260	17290	11440	8990	8910		19380	12790
2 min	5370	21260	12450	15810	15880	10470	7270	18200	13640	10390
4 min	7350	17640	13660	16670	12370	9850	5780	16990	9840	10390
Filtrate pH										
t_f = 1 min		1.8	4.2	4.1	5.2		4.3	4.5	2.6	2.3
2 min		1.6	4.2	4.1	4.9		4.3	4.5	2.6	2.2
4 min		1.5	4.3	4.1	5.0		4.3	4.5	2.6	2.2

APPENDIX C

TASK C - NEUTRAL pH ADJUSTMENT AFTER CONDITIONING

TABLE C-1

TASK C - pH ADJUSTED RAW SEPTAGE

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Total Solids, mg/l	24290	30140	15790	95200	39710	51290	81520	55800	70840	57080
Volatile Solids, mg/l	20020	17630	12400	60000	29580	39800	44400	39400	44350	38880
Initial pH/Adjusted pH	5.7/ 7.0	6.0/ 7.0	5.5/ 7.0	6.4/ 7.0	5.1/ 7.0	6.2/ 7.0	5.1/ 7.0	5.3/ 7.0	5.3/ 7.0	6.2/ 7.0
CST	87	214	65	550	355	204	106	211	179	

TABLE C-2

TASK C - pH ADJUSTED TREATED THICKENED SEPTAGE

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
pH Adjusted to pH 7±										
Total Solids, mg/l										
80 mg/l, Al(III) Dosage	45750		37690		31190					
100 mg/l, Al(III) Dosage	48260	97990	38060		33310	44060	75020	46600	74650	37390
120 mg/l, Al(III) Dosage	46160	101210	34880		33440	59940	74530	47200	59380	36830
140 mg/l, Al(III) Dosage	48710	111960	37610		32990	48220	77390	50200	60320	36700
160 mg/l, Al(III) Dosage		78870	35240		35530	51890	79600	41400	60740	41060
180 mg/l, Al(III) Dosage					32990	49670	83930	54400	67460	45530
200 mg/l, Al(III) Dosage		93890	36650		33830	47610	77820	49600	67070	38740
400 mg/l, Al(III) Dosage			37580	79600						
800 mg/l, Al(III) Dosage				63800						
140 mg/l, Fe(III) Dosage	46780	114800	39850	97600	31820	44760	73780	48800	67440	37510
180 mg/l, Fe(III) Dosage	52520	103170	41060	85600	31100	47710	78170	48800	62140	38570
220 mg/l, Fe(III) Dosage	47380	104740	34630	86800	33740	44540	79850	43800	59320	39194
260 mg/l, Fe(III) Dosage	52900	97590	37860	84200	33100	48460	79210	42200	63060	41090
300 mg/l, Fe(III) Dosage		100620	38640	82000	32000	55230	83790	49800	59240	38310
340 mg/l, Fe(III) Dosage		97100	42830	82000	36270	46550	74830	50000	60670	38020
400 mg/l, Fe(III) Dosage									63440	
pH2	36290	82850	33380	63000	32870	39730	36680	47800	58030	45270
pH3	46550	96860	35800	76800	38240	38890	51450	47000	58420	37170
Volatile Solids, mg/l										
80 mg/l, Al(III) Dosage	37930		28020		23170					
100 mg/l, Al(III) Dosage	40090	49700	28610		24680	33500	41620	31600	50590	25880
120 mg/l, Al(III) Dosage	38430	54370	25810		24790	46070	40680	33200	39850	25130
140 mg/l, Al(III) Dosage	40910	47020	27990		24350	36550	42610	35400	40130	25060
160 mg/l, Al(III) Dosage		49290	26150		26330	39600	43810	28800	40760	28330
180 mg/l, Al(III) Dosage					23870	37650	45850	37600	45090	31860
200 mg/l, Al(III) Dosage		47580	26290		24620	36300	44350	33800	45420	26750
400 mg/l, Al(III) Dosage			25590	47400						
800 mg/l, Al(III) Dosage				37200						
100 mg/l, Fe(III) Dosage	40820									
140 mg/l, Fe(III) Dosage	39960	55280	29170	59800	22920	34270	40360	33200	45790	24820
180 mg/l, Fe(III) Dosage	44270	54370	28900	52600	22130	36680	42460	33200	42150	25890
220 mg/l, Fe(III) Dosage	39380	54020	24640	53600	24680	34070	44260	30000	39830	26420
260 mg/l, Fe(III) Dosage	44620	50280	26950	51200	23570	37340	43400	28600	42740	28000
300 mg/l, Fe(III) Dosage		47640	27810	49000	22610	42810	47060	33600	39350	26550
340 mg/l, Fe(III) Dosage		48450	29050	51600	26250	35770	40740	35600	40790	27140
400 mg/l, Fe(III) Dosage									42950	
pH2	28750	42430	23350	38000	23610	29450	16750	31200	39220	23900
pH3	39420	51520	23480	49400	28860	29250	26060	32400	38930	23480

(continued)

TABLE C-2 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
CST after adjust to pH7										
80 mg/l, Al(III) Dosage	146		69		178					
100 mg/l, Al(III) Dosage	93	224	73		140	148	134	144	141	
120 mg/l, Al(III) Dosage	82	210	61		126	181	120	122	107	
140 mg/l, Al(III) Dosage	67	152	60		90	148	114	115	112	
160 mg/l, Al(III) Dosage		143	57		73	130	101	101	116	
180 mg/l, Al(III) Dosage					68	110	92	97	116	
200 mg/l, Al(III) Dosage		119	38		45	96	87	73	103	
400 mg/l, Al(III) Dosage			17	182						
800 mg/l, Al(III) Dosage				27						
140 mg/l, Fe(III) Dosage	53	203	47	287	201	124	106	142	127	
180 mg/l, Fe(III) Dosage	37	228	37	316	152	138	103	143	107	
220 mg/l, Fe(III) Dosage	32	222	31	323	153	115	85	123	100	
260 mg/l, Fe(III) Dosage	38	206	21	314	190	115	72	166	97	
300 mg/l, Fe(III) Dosage		225	20	326	164	143	62	107	100	
340 mg/l, Fe(III) Dosage		191	29	299	170	218	44	148	69	
400 mg/l, Fe(III) Dosage									58	
pH2	16	58	17	49	186	35	11	39	32	
pH3	23	101	17	159	193	59	16	108	64	
Initial pH/Adjusted pH										
80 mg/l, Al(III) Dosage	5.5/7		5.4/7.0		5.6/7.0					
100 mg/l, Al(III) Dosage	5.3/7	6.1/7.0	5.4/7.0		5.9/7.0	6.1/7.0	5.4/7.0	5.3/7.0	5.2/7.0	5.5/7.0
120 mg/l, Al(III) Dosage	5.3/7	6.2/7.0	5.3/7.0		5.6/7.0	6.0/7.0	5.5/7.0	5.8/7.0	5.2/7.0	5.6/7.0
140 mg/l, Al(III) Dosage	5.4/7	6.2/7.0	5.3/7.0		5.6/7.0	6.0/7.0	5.5/7.0	5.9/7.0	5.2/7.0	5.8/7.0
160 mg/l, Al(III) Dosage		6.3/7.0	5.2/7.0		5.2/7.0	6.0/7.0	5.4/7.0	5.7/7.0	5.2/7.0	6.1/7.0
180 mg/l, Al(III) Dosage					4.9/7.0	5.9/7.0	5.3/7.0	5.5/7.0	5.2/7.0	6.3/7.0
200 mg/l, Al(III) Dosage		6.2/7.0	4.9/7.0		4.7/7.0	5.7/7.0	5.3/7.0	5.3/7.0	5.2/7.0	6.2/7.0
400 mg/l, Al(III) Dosage			4.1/7.1	6.2/7.0						
800 mg/l, Al(III) Dosage				4.7/7.0						
140 mg/l, Fe(III) Dosage	5.5/7	6.1/7.0	5.4/7.0	6.3/7.0	5.0/7.0	5.8/7.0	5.1/7.0	5.1/7.0	5.3/7.0	5.1/7.0
180 mg/l, Fe(III) Dosage	5.4/7	6.2/7.0	5.3/7.1	6.2/7.0	5.0/7.0	5.7/7.0	5.1/7.0	5.3/7.0	5.2/7.0	5.0/7.0
220 mg/l, Fe(III) Dosage	5.4/7	6.1/7.0	5.3/7.0	6.3/7.0	4.9/7.0	5.7/7.0	5.1/7.0	5.1/7.0	5.2/7.0	5.1/7.0
260 mg/l, Fe(III) Dosage	5.5/7	6.2/7.0	5.3/7.0	6.3/7.0	4.9/7.0	5.7/7.0	5.0/7.0	5.1/7.0	5.2/7.0	5.4/7.0
300 mg/l, Fe(III) Dosage		6.0/7.0	5.3/7.0	6.2/7.0	4.9/7.0	5.6/7.0	5.0/7.0	5.5/7.0	5.2/7.0	5.4/7.0
340 mg/l, Fe(III) Dosage		6.1/7.0	5.3/7.0	6.2/7.0	4.9/7.0	6.2/7.0	5.0/7.0	5.3/7.0	5.2/7.0	5.5/7.0
pH2	2.3/7	2.9/7.0	2.1/7.2	2.2/7.0	2.2/7.0	4.0/7.0		2.5/7.0	3.5/7.0	2.4/7.0
pH3	5.1/7	5.6/7.0	3.9/7.0	5.1/7.0	5.6/7.0	5.3/7.0		5.0/7.0	4.9/7.0	4.9/7.0

TABLE C-3

TASK C - pH ADJUSTED TREATED SUPERNATANT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
COD, mg/l										
80 mg/l, Al(III) Dosage	2250									
100 mg/l, Al(III) Dosage	2570	2480							2970	
120 mg/l, Al(III) Dosage	1740	2500			320					
140 mg/l, Al(III) Dosage	2060	2520	3560	No pH Adj.	280			1640		
160 mg/l, Al(III) Dosage		2720	4560		280			1530		
180 mg/l, Al(III) Dosage					320		530	1450		
200 mg/l, Al(III) Dosage		2480	3200		280		610	1340		
400 mg/l, Al(III) Dosage			3160							
800 mg/l, Al(III) Dosage				1450						
140 mg/l, Fe(III) Dosage	1900	2720	3920					1910	2470	
180 mg/l, Fe(III) Dosage	2100	2560	2520		470			2020	2850	
220 mg/l, Fe(III) Dosage	2170	2480	2800		280			1930	2590	
260 mg/l, Fe(III) Dosage	2250	3380	4280		280		380	2000	5170	
300 mg/l, Fe(III) Dosage		2360	3680		320		450	1720	4487	
340 mg/l, Fe(III) Dosage		2730	4040		360		300	1570	4220	
400 mg/l, Fe(III) Dosage									4070	
pH2	2100	1690	2960	1840	510		300	1340	3840	
pH3	950	1970	3680	3450	360		530	650	1250	
Total Solids, mg/l										
80 mg/l, Al(III) Dosage	3090									
100 mg/l, Al(III) Dosage	3290	2890							4060	
120 mg/l, Al(III) Dosage	3060	3170								
140 mg/l, Al(III) Dosage	3480	3320	3690	No pH Adj.				2560		
160 mg/l, Al(III) Dosage		3760	5640					2620		
180 mg/l, Al(III) Dosage							3120	2930		
200 mg/l, Al(III) Dosage		4140	4260				2870	2840		3330
400 mg/l, Al(III) Dosage			5750							
800 mg/l, Al(III) Dosage				6350						
140 mg/l, Fe(III) Dosage	2230	2580	2690					1820	2450	
180 mg/l, Fe(III) Dosage	2350	2570	2850					1840	2780	
220 mg/l, Fe(III) Dosage	2240	2650	3010					1810	2730	
260 mg/l, Fe(III) Dosage	2500	2640	3480				1470	2200	2440	
300 mg/l, Fe(III) Dosage		2650	3030				1730	2240	2860	
340 mg/l, Fe(III) Dosage		2760	3210				1700	2360	3050	2330
400 mg/l, Fe(III) Dosage									3650	
pH2	5230	7070	7920	6390			3930	8020	6420	18110
pH3	3330	5290	6800	8120			5500	5160	3510	9190

(continued)

TABLE C-3 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Volatile Solids, mg/l										
80 mg/l, Al(III) Dosage	1250									
100 mg/l, Al(III) Dosage	940	1110							1760	
120 mg/l, Al(III) Dosage	780	1210								
140 mg/l, Al(III) Dosage	880	1170	530					670		
160 mg/l, Al(III) Dosage		1040	1550					620		
180 mg/l, Al(III) Dosage							840	660		
200 mg/l, Al(III) Dosage		1000	930				570	500		610
400 mg/l, Al(III) Dosage			810							
800 mg/l, Al(III) Dosage				970						
100 mg/l, Fe(III) Dosage	1340									
140 mg/l, Fe(III) Dosage	1170	1700	1850					830	1080	
180 mg/l, Fe(III) Dosage	1040	1580	1740					940	1040	
220 mg/l, Fe(III) Dosage	920	1690	1470					880	1100	
260 mg/l, Fe(III) Dosage	1000	1560	1730				520	830	820	
300 mg/l, Fe(III) Dosage		1440	1140				820	810	970	
340 mg/l, Fe(III) Dosage		1300	1860				860	760	670	970
400 mg/l, Fe(III) Dosage									480	
pH2	970	1080	1330	1110			430	690	1520	1030
pH3	740	1040	870	2640			670	740	860	1660
Initial pH/Adjusted pH										
80 mg/l, Al(III) Dosage			7.0/7.0		7.5/7.5					
100 mg/l, Al(III) Dosage		7.7/--	7.2/7.2		7.1/7.1	7.5/7.5	>7	7.1/7.1	6.8/7.0	7.9/-
120 mg/l, Al(III) Dosage		6.8/7.0	7.1/7.0		6.7/7.0	7.5/7.5	7.4/7.4	7.0/7.0	7.0/7.0	7.7/-
140 mg/l, Al(III) Dosage		6.4/7.0	6.2/7.0		6.5/7.0	7.5/7.5	7.4/7.4	5.8/7.0	7.0/7.0	7.8/-
160 mg/l, Al(III) Dosage		6.0/7.0	5.3/7.1		4.9/7.0	7.3/7.3	7.4/7.4	5.3/7.0	7.0/7.0	7.9/-
180 mg/l, Al(III) Dosage					4.5/7.0	7.2/7.2	6.7/7.0	5.1/7.0	7.6/7.6	7.4/-
200 mg/l, Al(III) Dosage		5.6/-	4.6/7.1		4.5/7.0	7.1/7.1	5.9/7.0	4.8/7.0	7.2/7.2	6.1/7.0
400 mg/l, Al(III) Dosage			4.0/7.0	7.8/7.8						
800 mg/l, Al(III) Dosage				4.3/7.8						
140 mg/l, Fe(III) Dosage		7.3/-	7.0/7.0	7.5/7.5	7.2/7.2	7.6/7.6	>7	6.3/7.0	6.0/7.0	7.8/-
180 mg/l, Fe(III) Dosage		7.2/-	7.6/7.6	7.2/7.2	6.7/7.0	7.4/7.4	>7	6.1/7.0	5.9/7.0	7.8/-
220 mg/l, Fe(III) Dosage		7.1/-	6.4/7.0	7.1/7.1	6.6/7.0	7.5/7.5	7.0/7.0	5.9/7.0	5.8/7.0	7.7/-
260 mg/l, Fe(III) Dosage		6.6/7.0	6.6/7.1	7.5/7.5	6.2/7.0	7.3/7.3	6.7/7.0	6.0/7.0	5.9/7.0	7.7/-
300 mg/l, Fe(III) Dosage		6.5/7.0	5.8/7.0	7.3/7.3	6.5/7.0	7.0/7.0	6.6/7.0	6.0/7.0	5.7/7.0	7.0/-
340 mg/l, Fe(III) Dosage		6.0/7.0	6.8/7.1	7.6/7.6	6.0/7.0	7.8/7.8	5.7/7.0	6.3/7.0	5.5/7.0	6.8/7.2
400 mg/l, Fe(III) Dosage									5.8/7.0	
pH2		2.6/7.0	1.8/7.0	2.1/7.0	2.2/7.0	3.0/7.0	.8/7.0	2.2/7.0	2.5/7.0	2.2/7.0
pH3		4.4/7.0	3.1/7.2	5.9/7.0	5.1/7.0	5.1/7.0	1.1/7.0	4.4/7.0	5.7/7.0	4.4/7.0

APPENDIX D

VACUUM FILTRATION OF SEPTAGE AND TWAS

TABLE D-1

TASK D - CAKE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l	140	160	140	400	100	160	180	180	180	180
CST	22	37	33	78	42	57	41	43	21	12
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	5	5	-	5	5	2	3	2	3	2
2 min	11	5	-	5	5	2	3	2	3	3
4 min	1	7	-	5	5	2	3	2	3	3
Dry Cake Weight, g										
t_f = 1 min	6.23	2.89	3.19	2.87	3.12	2.37	3.77	3.76	5.92	6.61
2 min	6.57	3.22	3.96	3.49	3.37	2.71	4.75	4.44	6.63	9.20
4 min	6.52	5.53	4.65	3.78	3.46	3.04	5.31	5.04	8.66	8.75
Cake Total Solids, %										
t_f = 1 min	8.9	9.93	10.5	9.6	8.4	9.6	9.5	10.4	10.4	12.1
2 min	10.4	11.48	10.9	10.3	9.6	11.6	9.3	11.8	12.2	12.1
4 min	13.6	12.78	11.9	12.2	11.1	11.8	10.7	13.2	12.3	13.1
Cake Volatile Solids, %										
t_f = 1 min	58.9	61.7	55.8	56.8	68.9	65.0	60.5	62.0	63.0	61.3
2 min	60.7	52.0	55.2	55.0	67.7	67.2	60.6	64.2	64.9	60.8
4 min	61.8	47.2	57.4	56.4		66.8	59.1	58.3	65.5	62.1
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min	2.06	.96	1.05	.95	1.03	.78	1.25	1.24	1.96	2.19
2 min	1.09	.53	.65	.58	.56	.45	.79	.73	1.10	1.52
4 min	.54	.46	.38	.31	.29	.25	.44	.42	.72	.72
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	5	5	-	5	2	1	3	2	3	2
2 min	5	5	-	5	2	1	3	2	3	2
4 min	7	5	-	5	7	1	3	2	3	2

(continued)

TABLE D-1 (Continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	4.82	2.80	2.89	3.87	2.31	2.41	3.57	3.65	5.87	8.73
2 min	5.35	3.28	3.79	5.70	2.58	2.59	4.38	3.93	7.10	8.25
4 min	6.91	4.24	3.87	2.90	3.71	2.51	4.74	3.77	6.98	8.05
Cake Total Solids, %										
t_f = 1 min	7.5	9.4	9.6	13.2	8.1	8.0	8.2	9.4	9.4	10.8
2 min	10.5	10.6	10.4	21.1	9.6	10.0	9.4	10.3	11.2	11.4
4 min	10.9	14.3	12.5	11.6	9.2	11.2	11.0	13.1	13.2	13.2
Cake Volatile Solids, %										
t_f = 1 min	60.8	65.9	64.0	66.7	68.4	67.2	61.3	61.1	61.5	63.3
2 min	58.2	61.2	56.6	76.0	67.1	66.0	60.3	60.6	64.4	61.6
4 min	80.7	57.0	56.5	55.9	69.0	68.1	62.0	60.7	63.3	61.7
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min	1.59	.93	.96	1.28	.76	.80	1.18	1.21	1.94	2.89
2 min	.88	.54	.63	.94	.43	.43	.72	.65	1.17	1.36
4 min	.57	.35	.32	.24	.31	.21	.39	.31	.58	.67

TABLE D-2

TASK D - CAKE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage	260	340	300	300	220	300	300	300	400	
CST	22	36	35	94	72	64	52	50	19	17
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	5	5	-	5	2.5	1	3	2	3	2
2 min	5	5	-	5	2.5	1	3	2	3	2
4 min	7.5	5	-	5	2.5	1	3	2	3	2
Dry Cake Weight, g										
t_f = 1 min	5.28	2.84	3.02	3.31	2.26	1.73	3.23	3.12	5.50	6.38
2 min	5.78	4.35	3.90	3.29	2.22	2.59	4.06	3.46	7.43	8.10
4 min	6.72	3.87	4.64		2.11	3.11	4.24	4.19	7.79	9.91
Cake Total Solids, %										
t_f = 1 min	8.0	10.5	10.1	12.3	8.3	11.2	8.6	10.9	10.6	9.3
2 min	9.7	12.6	10.7	10.6	10.2	10.3	9.2	11.0	10.9	11.2
4 min	11.0	11.2	11.0		15.6	11.8	11.3	11.0	12.4	12.6
Cake Volatile Solids, %										
t_f = 1 min		57.2	58.1	66.5	69.5	70.5	62.2	61.9	65.5	60.3
2 min		64.3	63.7	57.1	68.9	67.6	60.6	63.0	64.6	61.2
4 min		56.7	58.9		73.9	66.2	64.6	61.6	64.1	59.5
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min		.94	1.00	1.09	.75	.57	1.07	1.03	1.82	2.11
2 min		.72	.65	.54	.37	.43	.67	.57	1.23	1.34
4 min		.32	.38		.17	.26	.35	.35	.64	.82
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	5	5	-	5	2.5	1	3	2	3	2
2 min	5	5	-	5	2.5	2	3	2	3	2
4 min	7.5	5	-	5	2.5	2	3	2	3	2

(continued)

TABLE D-2 (Continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	3.45	2.65	3.21	2.40	2.11	1.92	3.29	3.38	5.74	7.06
2 min	4.74	3.38	3.45	3.32	2.49	2.53	3.81	3.60	6.15	7.24
4 min	5.11	4.22	3.76	3.09	2.60	3.27	4.48	4.51	8.13	8.11
Cake Total Solids, %										
t_f = 1 min	8.2	9.3	9.4	9.4	8.8	9.1	9.0	8.9	10.0	9.9
2 min	8.0	11.2	11.0	9.7	10.3	9.5	9.8	9.9	11.2	11.5
4 min	9.7	11.4	12.2	11.4	10.9	10.0	11.5	11.0	11.6	12.7
Cake Volatile Solids, %										
t_f = 1 min		63.0	64.1	63.3	68.3	69.8	63.5	60.1	63.9	60.3
2 min		52.8	60.9	56.9	65.9	67.6	65.6	60.0	60.8	59.8
4 min		54.5	62.1	57.9	67.7	65.4	65.4	60.5	59.9	60.4
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min		.88	1.06	.79	.70	.63	1.09	1.12	1.90	2.33
2 min		.56	.57	.55	.41	.42	.63	.60	1.02	1.20
4 min		.35	.31	.26	.21	.27	.37	.57	.67	.67

TABLE D-3

TASK D - CAKE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	3	3	2	
CST	23	24	25	71	52	40	46	43	14	15
Filtration Pressure, (lb/in^2)	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	10	5	-	5	5	2	3	2	2	2
2 min	17	5	-	5	2.5	2	3	2	2	2
4 min	22	5	-	5	2.5	2	3	2	2	2
Dry Cake Weight, g										
t_f = 1 min	6.14	3.59	2.53	2.81	2.20	2.92	3.09	2.80	4.51	6.56
2 min	8.73	4.40	2.88	2.85	2.19	2.67	3.65	4.05	6.63	6.77
4 min	11.66	4.53	4.09	2.57	2.77	3.86	4.50	5.00	8.45	9.25
Cake Total Solids, %										
t_f = 1 min	10.3	10.7	13.4	9.7	8.1	9.0	9.4	10.3	12.9	11.5
2 min	10.0	12.6	14.9	10.9	9.9	8.3	10.6	10.6	11.6	13.3
4 min	12.0	14.2	14.0	14.8	11.1	12.1	10.9	11.2	12.3	12.8
Cake Volatile Solids, %										
t_f = 1 min	83.3	53.2	62.1	53.7	68.2	63.7	65.7	60.4	63.9	62.2
2 min		55.8	56.6	54.0	67.6	67.4	61.4	59.8	61.1	60.1
4 min	72.3	58.5	62.8	53.7	68.2	67.1	61.6	61.2	59.2	61.4
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min	2.03	1.19	.84	.93	.73	.97	1.02	.93	1.49	2.17
2 min		.73	.48	.47	.36	.44	.60	.67	1.10	1.12
4 min	96	.37	.34	.21	.23	.32	.37	.41	.70	.76
Filtration Pressure, (lb/in^2)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	10	5	-	-	2.5	1	3	2	2	2
2 min	10	5	-	-	2.5	2	3	2	2	2
4 min	10	5	-	-	2.5	2	3	2	2	2

(continued)

TABLE D-3 (Continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	6.69	3.11	2.70	2.10	2.13	2.48	2.95	3.44	4.63	6.65
2 min	8.34	4.33	3.05	2.66	2.17	3.08	3.54	3.85	6.96	7.09
4 min	9.87	4.61	3.63	2.94	2.52	3.89	4.37	5.21	7.07	9.20
Cake Total Solids, %										
t_f = 1 min	9.7	10.9	11.8	13.7	8.3	10.0	9.9	8.8	10.4	11.1
2 min	10.5	12.7	13.7	11.4	10.0	10.9	10.3	10.2	10.9	12.3
4 min	11.9	18.3	13.8	12.6	10.9	11.4	11.0	10.3	13.1	12.7
Cake Volatile Solids, %										
t_f = 1 min	64.0	56.0	56.0	53.8	70.4	67.3	62.7	61.6	60.5	57.9
2 min	65.5	58.3	57.9	55.6	68.7	65.3	65.3	64.4	59.8	58.1
4 min	61.5	62.2	57.6	59.2	70.2	65.8	61.6	61.2	60.3	57.9
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min	2.21	1.03	.89	.69	.70	.82	.98	1.14	1.53	2.20
2 min	1.38	.72	.50	.44	.36	.51	.59	.64	1.15	1.17
4 min	.82	.38	.30	.24	.21	.32	.36	.43	.58	.76

TABLE D-4

TASK D - CAKE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l		160	140	400	100	160	180	180	180	
CST		83	53	56	58	100	53	47	87	32
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	1	2.5	2.5	5	2.5	1	3	3	3	2
2 min	1	2.5	2.5	5	2.5	1	3	3	3	1
4 min	1	1	2.5	5	2.5	1	3	2	2	2
Dry Cake Weight, g										
t_f = 1 min	2.06	2.33	4.19	3.33	2.55	1.57	3.54	3.67	3.55	2.60
2 min	2.80	3.21	3.00	2.97	2.52	2.21	4.04	4.20	3.08	2.38
4 min	2.58	2.23	2.31	5.46	2.59	2.32	4.79	4.50	3.33	2.04
Cake Total Solids, %										
t_f = 1 min	9.4	16.2	30.2	13.9	12.3	12.7	13.1	13.4	15.3	18.2
2 min	12.6	16.7	21.3	12.5	13.2	13.7	14.8	13.9	17.4	22.6
4 min	18.6	26.0	25.1	19.5	15.5	17.7	16.1	17.9	22.8	24.1
Cake Volatile Solids, %										
t_f = 1 min	69.8	50.2	38.7	53.8	73.7	72.6	62.4	68.9	68.7	68.1
2 min	63.9	60.4	63.3	47.1	72.6	72.9	64.4	66.4	69.8	70.2
4 min	65.4	50.8	67.4	63.0	73.4	72.8	62.2	68.9	71.2	71.1
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min	.68	.77	1.39	1.10	.84	.52	1.17	1.21	1.17	.86
2 min	.46	.53	.50	.49	.42	.37	.67	.69	.51	.39
4 min	.21	.18	.19	.45	.21	.19	.40	.37	.28	.17
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	1	NM	2.5	2.5	2.5	1	3	3	3	2
2 min	1	NM	2.5	2.5	1	1	3	3	3	2
4 min	1	NM	5	2.5	1	2	3	3	2	2

(continued)

TABLE D-4 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min		1.61	2.25	2.57	1.88	1.74	3.87	3.47	3.71	2.29
2 min	2.16	1.33	2.10	2.17	1.65	1.68	4.05	3.39	3.75	1.32
4 min	2.68	1.24	4.51	2.50	1.84	2.68	4.31	4.39	2.64	2.86
Cake Total Solids, %										
t_f = 1 min		14.0	17.5	13.2	12.3	10.3	10.8	11.7	14.3	15.6
2 min	14.7	19.8	20.4	13.5	14.4	11.3	13.0	13.9	16.4	16.0
4 min	17.0	18.6	18.3	19.3	16.6	12.5	14.8	14.4	16.2	19.7
Cake Volatile Solids, %										
t_f = 1 min		54.7	60.9	61.5	71.8	73.6	62.8	67.4	69.5	69.9
2 min	55.7	50.1	64.8	69.1	73.3	72.6	64.4	65.8	69.9	70.5
4 min	60.2	51.7	61.6	55.6	73.9	72.4	61.7	67.7	70.8	69.2
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min		.53	.75	.85	.62	.58	1.28	1.15	1.23	.76
2 min	.36	.22	.35	.36	.27	.28	.67	.56	.62	.22
4 min	.22	.10	.37	.21	.15	.22	.36	.36	.22	.24

TABLE D-5

TASK D - CAKE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l	260	340	300	300	220	300	300	300	400	
CST	22	95	53	123	126	125	62	129	66	96
Filtration Pressure, (lb/in^2)	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	NM	NM	1	2.5	2.5	1	3	2	2	3
2 min	NM	NM	2.5	2.5	2.5	2	3	2	2	3
4 min	1	NM	2.5	2.5	2.5	1	3	2	3	2
Dry Cake Weight, g										
t_f = 1 min	2.21	1.28	1.92	2.28	1.40	1.93	3.44	2.67	2.87	2.93
2 min	2.46	1.36	1.50	2.93	1.56	1.91	3.71	2.82	4.30	2.09
4 min	2.37	1.15	2.38		2.54	1.66	5.18	4.04	4.71	1.67
Cake Total Solids, %										
t_f = 1 min	8.0	19.0	18.4	13.4	12.8	13.9	12.1	12.9	15.6	15.8
2 min	10.9	23.0	22.6	15.9	14.2	14.5	14.1	15.3	16.6	17.8
4 min	14.4	24.1	22.2		12.7	19.3	13.8	14.4	22.1	23.3
Cake Volatile Solids, %										
t_f = 1 min		50.7	66.7	57.9	72.1	72.5	62.8	66.3	70.4	68.6
2 min		55.3	68.8	58.7	71.2	73.3	62.0	67.7	70.0	71.3
4 min		50.2	74.9		70.1	74.7	63.3	66.6	70.5	71.9
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min		.42	.64	.75	.46	.64	1.14	.88	.95	.97
2 min		.22	.25	.48	.26	.32	.61	.47	.71	.35
4 min		.09	.20		.21	.14	.43	.33	.39	.14
Filtration Pressure, (lb/in^2)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	NM	NM	2.5	2.5	1	1	2	2	3	2
2 min	NM	NM	2.5	2.5	1	1	3	2	3	1
4 min	NM	NM	2.5	2.5	1	1	2	2	3	1

(continued)

TABLE D-5 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	1.16	1.38	1.65		1.38	1.69	2.83	2.77	4.35	1.67
2 min	0.85	1.21	1.99	2.85	1.41	1.55	3.29	2.66	4.33	1.46
4 min	0.57	1.18	2.83	3.25	1.79	1.94	3.28	2.88	3.66	1.15
Cake Total Solids, %										
t_f = 1 min	4.0	15.8	16.1		12.5	11.1	11.9	11.2	13.1	13.2
2 min	7.7	19.9	18.5	11.9	12.0	13.1	13.4	13.8	14.0	17.2
4 min	9.7	19.5	20.2	16.3	13.3	16.4	17.5	16.4	19.9	18.8
Cake Volatile Solids, %										
t_f = 1 min		54.0	62.4		71.7	72.8	61.8	67.5	69.0	70.1
2 min		74.5	63.3	60.4	73.1	72.3	62.9	66.2	66.5	70.6
4 min		51.6	61.5	55.4	73.2	74.7	63.4	69.1	65.9	74.1
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min		.46	.54		.46	.56	.94	.92	1.44	.55
2 min		.20	.33	.47	.23	.26	.54	.44	.72	.24
4 min		.10	.23	.27	.15	.16	.27	.24	.30	.10

TABLE D-6

TASK D - CAKE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	3	3	2	
CST	46	61	76	110	134	52	51	170	41	63
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	NM	NM	2.5	2.5	1	1	2	NM	3	2
2 min	1	NM	2.5	2.5	1	1	2	2	3	2
4 min	1	NM	2.5	2.5	1	1	3	2	3	2
Dry Cake Weight, g										
t_f = 1 min	3.01	1.06	2.67	3.48	1.18	2.10	2.93	1.40	3.58	3.26
2 min		.93	1.89	1.87	1.22	1.78	3.51	2.56	3.88	2.29
4 min	3.60	1.11	2.41	3.31	1.13	2.10	5.14	2.57	3.63	2.09
Cake Total Solids, %										
t_f = 1 min	14.8	21.3	19.0	27.8	13.8	16.8	12.3	15.7	17.6	18.5
2 min		22.4	23.8	16.4	16.4	21.8	13.6	14.0	18.8	22.3
4 min	19.1	27.2	24.7	18.2	21.4	22.6	13.4	19.6	22.3	24.4
Cake Volatile Solids, %										
t_f = 1 min	65.6	51.0	70.9	77.3	76.3	74.3	64.2	75.7	67.0	69.6
2 min		51.3	68.2	55.1	73.8	74.7	64.4	68.8	66.8	72.5
4 min	76.5	48.7	37.4	56.8	76.1	75.7	63.0	66.9	67.2	68.9
Cake Yield, $(lb/ft^2\text{-}hr)$										
t_f = 1 min	1.00	.35	.88	1.15	.39	.69	.97	.46	1.18	1.08
2 min		.15	.31	.31	.20	.29	.58	.42	.64	.38
4 min	0.30	.09	.20	.27	.09	.17	.42	.21	.30	.17
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	1	NM	1	2.5	1	1	3	NM	2	2
2 min	2.5	NM	1	2.5	1	1	2	1	2	2
4 min	1	NM	1	2.5	NM	1	2	1	2	2
Dry Cake Weight, g										
t_f = 1 min	3.78	1.03	1.46	2.34	1.16	1.76	2.96	1.66	2.70	1.65
2 min	3.34	.92	1.59	2.34	1.45	1.65	2.91	1.78	2.63	1.19
4 min	2.08	.95	1.36	2.31	1.28	2.03	3.51	2.40	3.16	1.43

(continued)

TABLE D-6 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Cake Total Solids, %										
t_f = 1 min	11.9	17.8	18.4	11.1	11.5	15.1	11.5	12.0	15.1	14.7
2 min	13.1	21.7	20.5	16.0	12.2	17.1	17.5	12.4	19.5	18.4
4 min	16.1	21.1	22.4	16.6	18.6	17.6	13.7	15.0	20.3	20.0
Cake Volatile Solids, %										
t_f = 1 min	72.0	51.1	59.5	59.4	75.0	76.7	63.9	69.3	65.9	66.7
2 min	72.9	65.9	61.6	59.0	73.1	74.6	68.7	70.8	67.3	68.9
4 min	69.7	55.2	63.9	71.4	75.0	75.9	63.3	70.4	67.4	74.8
Cake Yield, (lb/ft^2-hr)										
t_f = 1 min	1.25	.34	.48	.77	.38	.58	.98	.55	.89	.55
2 min	.55	.15	.26	.39	.24	.27	.48	.29	.43	.20
4 min	.17	.08		.19	.11	.17	.29	.20	.26	.12

TABLE D-7

TASK D - SEPTAGE AND TWAS MIXTURE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)		
Total Solids, mg/l	42080	39000	45060	43670	35070	40910	44960	44600		
Volatile Solids, mg/l	30300	25810	27850	25900	23640	27320	28490	29820		
CST			33					42		
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)		
Total Solids, mg/l	as	38970	45060	44010	36430	41830	45140	46470		
Volatile Solids, mg/l	above	25830	27850	25900	24470	27940	28600	31070		
CST			35					50		
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4		
Total Solids, mg/l	as	38980	45060	44570	35160	40760	44870	44660		
Volatile Solids, mg/l	above	25820	27850	25920	23700	27220	28430	29870		
CST			25					43		

TABLE D-8

TASK D - SEPTAGE AND TWAS MIXTURE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)		
Total Solids, mg/l	40120	39830	43400	49450	25290	42430	54580	46970		
Volatile Solids, mg/l	30420	25220	22500	25640	17630	30140	33480	32670		
CST			53					47		
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)		
Total Solids, mg/l	as	39720	43400	51540	26410	45040	55250	48560		
Volatile Solids, mg/l	above	25260	22500	25660	18320	31990	33890	33780		
CST			53					129		
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4		
Total Solids, mg/l	as	39890	43400	47430	25460	40360	54250	44880		
Volatile Solids, mg/l	above	25170	22500	25610	17490	28670	33280	31220		
CST			76					170		

TABLE D-9

TASK D - TWAS CAKE CHARACTERISTICS, NO SEPTAGE

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
COD, mg/l		36450						41412	35270	
Total Solids, mg/l		38560	47510	40410		40390	40220	44570	44220	51540
Volatile Solids, mg/l		26110	30930	26040		25830	26030	29000	28680	32540
CST	14	55	13	44	96			18	12	18
pH			6.8						6.2	
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	2		7.5	7.2	2.5	5	3	3	10	7
2 min	1.5		7.5	7.2	2.5	5	3	7	10	7
4 min	2.5		7.5	5	2.5	4	3	10	11	7
Dry Cake Weight, g										
t_f = 1 min	5.74	2.81	1.84	3.20	1.98	2.96	2.88	3.43	6.96	10.93
2 min	4.68	2.34	2.41	3.92	2.29	3.35	3.92	6.30	9.21	11.65
4 min	7.19	3.44	3.78	3.08	1.95	3.58	4.30	13.39	11.29	13.88
Cake Total Solids, %										
t_f = 1 min	9.6	9.9	8.7	7.0	9.0	8.5	9.0	11.2	9.5	9.0
2 min	12.3	11.3	8.2	7.3	9.1	9.6	8.8	9.5	9.1	10.9
4 min	10.4	11.1	7.8	9.4	11.6	10.3	10.0	11.9	9.4	11.4
Cake Volatile Solids, %										
t_f = 1 min	59.9	56.1	64.6	66.1	65.7	63.2	61.5	58.9	58.6	60.8
2 min	60.6	59.2	61.2	61.7	62.5	62.7	64.5	58.3	55.2	56.9
4 min	58.0	54.7	60.0	66.4	68.7	62.0	61.4	67.7	56.1	59.4
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.90	0.93	.61	1.06	.65	.98	.95	1.13	2.30	3.61
2 min	.77	0.39	.40	.65	.38	.55	.65	1.04	1.52	1.93
4 min	.59	0.28	.31	.25	.16	.30	.36	1.11	.93	1.15
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	2		1	1	2.5	5	3	6	6	7
2 min	2		1	1	2.5	5	3	6	6	7
4 min	2		1	1	2.5	4	3	6	7	7

(continued)

TABLE D-9 (Continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	5.50	1.75	1.83	2.21	2.19	2.98	3.55	5.71	4.85	11.43
2 min	6.69	2.94	3.01	2.78	2.64	3.45	3.48	7.38	4.58	14.43
4 min	9.49	2.20	3.31	3.28	2.60	3.46	3.82	6.00	8.24	27.65
Cake Total Solids, %										
t_f = 1 min	9.1	9.4	6.0	8.0	7.6	8.7	7.6	8.5	9.7	11.2
2 min	10.0	9.3	7.4	7.6	11.6	8.2	8.8	8.7	11.8	11.4
4 min	10.0	10.8	9.0	8.3	10.3	9.6	9.7	10.7	10.8	14.8
Cake Volatile Solids, %										
t_f = 1 min	59.0	66.4	62.5	63.7	66.2	61.4	64.5	59.7	54.2	57.0
2 min	59.2	56.3	60.1	65.8	64.0	62.9	64.4	58.4	56.6	62.4
4 min	58.1	52.9	59.1	61.5	63.1	62.4	63.6	59.2	53.3	72.6
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.82	.58	.61	.73	.72	.99	1.17	1.89	1.60	3.78
2 min	1.11	.49	.50	.46	.44	.57	.58	1.22	.76	2.39
4 min	.78	.18	.27	.27	.21	.29	.32	.50	.68	2.29

TABLE D-10

TASK D - TWAS AND SEPTAGE MIXTURE CHARACTERISTICS, MODE II, 20%/80% AND 50%/50% MIXTURES

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
20% SEPTAGE/80% TWAS										
Coagulants Used - Al(III), Fe(III) and H_2SO_4										
Total Solids, mg/l	34570	39210	36990	40050	29740	38300	41100	36690		
Volatile Solids, mg/l	24530	25660	29830	25820	20370	25580	26040	24530		
CST			18							
50% SEPTAGE/50% TWAS										
Coagulants Used - Al(III), Fe(III) and H_2SO_4										
Total Solids, mg/l	25890	40220	27700	39510	19840	35540	42470	28960		
Volatile Solids, mg/l	19630	24940	15750	25510	14280	25250	26060	20150		
CST			99							

TABLE D-11

TASK D - CAKE CHARACTERISTICS, MODE II, 20% SEPTAGE/80% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l	140	160	140	400	100	160	180	180	180	180
CST	17	24	19	104	31	26	21	18	14	12
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	17	2.5		2.5			3		3	1
2 min	15	2.5		2.5			3		3	1
4 min	12	5		2.5			3		3	1
Dry Cake Weight, g										
t_f = 1 min	7.69	2.28	2.76	1.94	1.51	2.65	4.11	3.46	6.56	4.16
2 min	6.43	3.23	3.24	1.00	1.31	3.16	4.15	3.68	6.55	5.19
4 min	5.64	3.10	3.35	2.54	1.17	3.08	5.41	5.08	6.61	6.31
Cake Total Solids, %										
t_f = 1 min	11.3	13.7	13.1	8.6	14.7	10.4	10.4	13.9	11.6	15.9
2 min	12.6	15.9	14.6	15.3	17.4	13.0	13.8	14.8	13.0	15.9
4 min	14.4	18.1	16.5	10.6	20.9	15.5	13.6	14.5	14.6	15.3
Cake Volatile Solids, %										
t_f = 1 min	60.4	52.8	63.2	66.0	68.9	66.0	59.6	63.6	56.9	66.8
2 min	60.4	53.5	60.1	72.0	70.2		60.7	64.7	58.0	67.1
4 min	61.7	51.8	61.8	66.9	70.1	67.2	59.5	61.6	58.4	68.3
Cake Yield, lb/ft^2-hr										
t_f = 1 min	2.54	.75	.91	.64	.50	.88	1.36	1.14	2.17	1.38
2 min	1.06	.53	.54	.17	.22	.52	.69	0.61	1.08	.86
4 min	.47	.26	.28	.21	.10	.25	.45	0.42	.55	.52
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	7	5		2.5			2		3	1
2 min	12	5		2.5			3		3	1
4 min	7	5		2.5			3		3	1

(continued)

TABLE D-11 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	5.69	2.59	2.65	1.81	1.19	2.30	3.65	3.40	5.48	4.64
2 min	6.67	3.08	3.56	1.42	1.12	2.80	4.52	4.38	6.98	5.06
4 min	5.59	3.57	3.31	1.22	1.48	2.91	6.73	5.77	6.94	3.67
Cake Total Solids, %										
t_f = 1 min	11.8	10.7	10.6	7.8	12.7	10.1	11.9	11.4	12.2	14.5
2 min	11.7	14.6	13.6	11.0	15.9	12.0	12.6	13.5	12.8	16.2
4 min	14.4	16.1	15.9	13.2	16.7	14.5	13.4	13.8	14.4	18.2
Cake Volatile Solids, mg/l										
t_f = 1 min	61.6	55.1	63.0	68.5	68.9	66.1	59.7	63.5	57.1	67.5
2 min	59.4	55.3	69.2	69.7	70.2	64.3	60.2	62.3	57.6	67.4
4 min	64.4	55.4	68.1	69.7	70.1	65.3	62.0	61.2	59.7	67.9
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.88	.86	.88	.60	.50	.76	1.21	1.12	1.81	1.53
2 min	1.10	.51	.59	.23	.22	.46	.75	0.72	1.15	.84
4 min	.46	.29	.27	.10	.10	.24	.56	0.48	.57	.30

TABLE D-12

TASK D - CAKE CHARACTERISTICS, MODE II, 20% SEPTAGE/80% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l	260	340	300	300	220	300	300	300	400	340
CST	17	25	20	131	26	26	18	16	13	108
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	1	2.5			2.5		2		3	1
2 min	1	2.5			2.5		2		3	1
4 min	1	2.5			2.5		3		3	NM
Dry Cake Weight, g										
t_f = 1 min	4.57	2.07	2.37	1.43	1.72	2.50	3.48	3.49	4.74	.86
2 min	4.99	3.07	2.84	1.27	1.74	3.53	3.61	4.54	5.26	.63
4 min	5.51	1.96	2.79	1.50	.96	3.22	4.76	3.66	7.17	1.06
Cake Total Solids, %										
t_f = 1 min	12.6	15.0	15.3	13.0	10.9	12.6	12.3	13.7	14.7	10.0
2 min	14.1	15.9	16.3	14.9	15.0	12.0	14.9	14.0	15.3	13.3
4 min	14.6	21.2	17.7	18.6	21.9	14.9	14.5	16.7	14.7	17.2
Cake Volatile Solids, %										
t_f = 1 min	58.1	58.5	62.5	69.2	69.8	67.2	62.6	62.8	59.9	69.8
2 min	64.1	53.5	62.8	70.9	69.5	64.6	62.3		61.4	69.8
4 min	62.5	53.4	63.6	70.0	68.8	65.5	60.5	67.5	58.4	67.9
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.51	.68	.78	.47	.57	.83	1.15	1.15	1.57	.28
2 min	.83	.51	.47	.21	.29	.58	.60	.75	.87	.10
4 min	.46	.16	.23	.12	.08	.27	.39	.30	.59	.09
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	.3			.1			.08		.12	NM
2 min	.3	.1		.1			.08		.12	NM
4 min	.3	.1		.1			.08		.12	NM

(continued)

TABLE D-12 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	5.07	1.94	2.32	1.93	1.46	2.53	3.25	3.19	5.95	1.07
2 min	5.88	2.28	2.68	1.83	1.08	2.88	4.11	3.96	5.99	1.46
4 min	6.86	2.70	3.61	1.94	1.47	3.40	5.51	4.79	6.02	1.69
Cake Total Solids, %										
t_f = 1 min	12.0	11.6	13.5	8.2	11.5	12.1	12.6	11.4	12.5	8.4
2 min	13.0	16.5	15.1	9.2	15.3	12.9	12.8	13.7	14.2	12.1
4 min	14.1	16.4	15.4	10.4	17.1	14.3	14.6	15.1	15.3	16.7
Cake Volatile Solids, %										
t_f = 1 min	65.8	58.3	63.0	65.8	67.8	66.4	61.5	63.6	58.2	71.0
2 min	61.6	55.3	63.3	66.1	68.5	63.9	61.6	60.9	59.3	67.1
4 min	69.7	58.3	65.7	67.5		67.7	63.3	61.0	59.5	68.1
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.68	.16	.77	.64		.84	1.07	1.05	1.97	.35
2 min	.97	.38	.44	.30		.48	.68	.65	.99	.24
4 min	.57	.22	.30	.16		.28	.46	.40	.50	.14

TABLE D-13

TASK D - CAKE CHARACTERISTICS, MODE II, 20% SEPTAGE/80% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	3	3	2	2
CST	23	12	16	114	18	113	24	23	28	26
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	5	5		2.5			2		1	NM
2 min	5	5		2.5			2		1	NM
4 min	5	5		2.5			3		1	NM
Dry Cake Weight, g										
t_f = 1 min	5.76	4.31	2.77	1.69	1.56	1.08	3.32	2.44	1.99	.92
2 min	6.54	4.67	3.11	1.81	1.59	2.23	4.12	3.16	1.17	.95
4 min	6.83	5.93	2.04	3.04	1.55	1.37	4.99	3.60	2.10	1.00
Cake Total Solids, %										
t_f = 1 min	13.5	17.2	15.2	8.9	16.9	9.9	13.9	15.2	20.0	23.5
2 min	15.5	18.1	14.6	9.6	19.9	17.3	14.3	16.3	26.3	25.0
4 min	17.1	18.6	22.0	15.4	21.2	23.7	15.0	16.5	24.0	25.3
Cake Volatile Solids, %										
t_f = 1 min	57.6	53.8	63.0	65.1	71.2	74.1	63.3	67.2	76.4	71.7
2 min	58.9	53.0	70.6	64.6	72.3	76.7	60.9	67.1	78.6	79.0
4 min	63.0	53.2	68.9	76.0	71.0	76.6	61.9	63.6	74.3	73.0
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.90	1.43	.92	.56	.52	.36	1.10	.81	.66	.30
2 min	1.08	.77	.51	.30	.26	.37	.68	.52	.19	.16
4 min	.57	.49	.17	.25	.13	.11	.41	.30	.17	.08
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	5	7.5		2.5			2		NM	NM
2 min	12.5	7.5		2.5			2		NM	NM
4 min	7.5	7.5		1			2		NM	NM

(continued)

TABLE D-13 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	5.92	6.12	2.33	1.65	1.38	1.45	3.17	2.56	.74	1.11
2 min	9.06	5.41	2.51	1.96	1.68	1.31	3.83	3.17	.80	.78
4 min	8.06	7.06	2.25	1.62	1.36	1.72	4.81	4.21	.68	1.21
Cake Total Solids, %										
t_f = 1 min	14.3	15.9	14.2	8.0	13.1	14.7	13.6	11.8	19.5	18.8
2 min	13.1	17.0	16.7	8.9	16.1	17.9	14.5	13.9	22.7	18.4
4 min	16.2	16.8	19.2	11.6	20.1	19.2	14.8	14.8	25.0	23.4
Cake Volatile Solids, %										
t_f = 1 min	60.7	54.5	61.6	66.7	71.0	75.2	62.2	64.8	78.4	69.4
2 min	60.4	55.2	65.2	65.8	71.4	75.6	59.0	65.3	76.3	70.5
4 min	66.1	58.7	64.9	66.7	69.9	76.2	58.8	65.3	79.4	74.4
Cake Yield, lb/ft^2-hr										
t_f = 1 min	1.96	2.02	.77	.55	.46	.48	1.05	.85	.24	.37
2 min	1.50	.89	.42	.32	.28	.22	.63	.52	.13	.13
4 min	.67	.58	.19	.13	.11	.14	.40	.35	.06	.10

TABLE D-14

TASK D - CAKE CHARACTERISTICS, MODE II, 50% SEPTAGE/50% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage	140	160	140	400	100	160	180	180	180	180
CST	25	118	126	407	59	70	19	39	28	15
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	2.5	NM		NM		NM	3		1.5	1
2 min	2.5	NM		NM		1	3		1	1
4 min	2.5	NM		NM		NM	3		1	NM
Dry Cake Weight, g										
t_f = 1 min	3.16	.58	1.00	4.97	.43	1.64	3.57	1.16	2.19	2.18
2 min	3.21	.48	1.18	1.29	.60	1.99	4.85	1.30	1.95	1.13
4 min	3.33	.75	1.90	1.03	.59	1.43	5.06	1.22	1.91	1.22
Cake Total Solids, %										
t_f = 1 min	14.1	23.2	20.7	47.2	17.6	18.1	17.9	21.4	23.2	22.0
2 min	16.8	17.2	22.2	5.7	20.1	16.7	19.3	21.6	26.1	23.8
4 min	19.3	38.5	22.9	19.3	20.5	22.4	21.2	22.6	27.9	24.3
Cake Volatile Solids, %										
t_f = 1 min	63.9	57.5	74.1		72.1	72.0	59.4	74.1	67.6	70.6
2 min	80.0	37.1	74.5		71.7		58.1	75.4	68.7	69.9
4 min	70.2	73.4	75.4	69.9	76.3	73.4	58.5	73.8	67.0	69.7
Cake Yield lb/ft^2										
t_f = 1 min	26	5	8	9	3.5	13	29	9	18	18
2 min	13	2	5	5	2.5	8	20	5	8	5
4 min	7.5	1.5	4	2	1	3	10	2.5	4	2.5
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	2.5	NM		NM		1	3		1	1
2 min	NM	NM		NM		1	3		1	NM
4 min	5	NM		NM		NM	3		2	NM

(continued)

TABLE D-14 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	1.72	.33	1.25	1.18	.44	1.40	4.00	1.37	3.24	1.63
2 min	1.03	.28	1.25	2.10	.66	1.28	4.40	1.74	1.74	1.36
4 min	1.98	.50	1.90	1.79	.63	1.35	3.97	2.40	2.76	1.40
Cake Total Solids, %										
t_f = 1 min	13.6	16.2	16.2	10.1	14.5	14.6	17.5	19.2	12.9	19.5
2 min	13.7	13.4	18.8	8.1	15.7	18.1	18.7	18.0	22.3	20.2
4 min	18.1	23.7	21.0	10.8	17.1	17.8	22.0	18.3	22.4	20.6
Cake Volatile Solids, %										
t_f = 1 min	74.0	61.3	74.3	68.6	70.5	70.7	60.0	71.5	61.7	68.7
2 min	63.1	63.5	75.2	67.1	71.2	73.4	61.1	72.4	66.1	68.4
4 min	65.1	66.9	74.5	65.4	73.0	72.6	63.7	72.5	65.2	68.6
Cake Yield, lb/ft^2-hr										
t_f = 1 min	.57	.11	.41	.39	.15	.46	1.32	.45	1.07	.54
2 min	.17	.05	.21	.35	.11	.21	.73	.29	.29	.22
4 min	.16	.04	.16	.15	.05	.11	.33	.20	.23	.12

TABLE D-15

TASK D - CAKE CHARACTERISTICS, MODE II, 50% SEPTAGE/50% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l	260	300	300	300	220	300	300	300	400	340
CST	24	145	116	396	103	82	28	27	26	24
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	NM	NM		NM		1	2		2	NM
2 min	NM	NM		NM		1	2		2	NM
4 min	NM	NM		NM		1	2		3	1
Dry Cake Weight, g										
t_f = 1 min	.98	.40	.85	1.76	.46	1.55	2.44	1.57	3.35	1.19
2 min	.74	.55	1.16	1.95	.50	1.70	2.98	1.04	2.37	.92
4 min	.90	.43	.86	1.92	.39	2.36	3.23	1.44	3.04	1.65
Cake Total Solids, %										
t_f = 1 min	18.8	24.1	20.8	8.4	17.8	16.7	19.2	21.4	21.2	22.7
2 min	17.2	32.9	22.9	9.5	20.8	18.9	19.7	21.7	22.0	23.4
4 min	20.5	28.1	24.5	11.8	21.6	19.4	23.5	22.5	24.6	25.5
Cake Volatile Solids, %										
t_f = 1 min	64.5	63.4	75.7	67.6	71.7	69.7	62.7	72.6	65.1	68.1
2 min	70.8	42.5	74.5	67.7	78.0	72.9	61.1	73.1	68.4	68.5
4 min	66.7	71.9	74.7	68.2	71.8	72.0	63.8	75.0	67.1	70.3
Cake Yield, lb/ft^2-hr										
t_f = 1 min	.32	.13	.28	.58	.15	.51	.81	.52	1.11	.39
2 min	.12	.09	.19	.32	.08	.28	.49	.17	.39	.15
4 min	.08	.04	.07	.16	.03	.20	.27	.12	.25	.14
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	NM	NM		NM		1	2		1	1
2 min	NM	NM		NM		NM	2		2	NM
4 min	NM	NM		NM		1	2		2	NM

(continued)

TABLE D-15 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	.89	.24	1.23	1.31	.56	1.61	2.16	2.42	1.78	1.41
2 min	.94	.27	.82	1.25	.51	1.40	2.65	1.38	2.67	.68
4 min	.62	.32	1.32	1.09	.43	1.62	2.65	1.64	2.63	.96
Cake Total Solids, %										
t_f = 1 min	15.8	17.6	21.8	11.8	15.5	15.4	17.9	27.4	19.9	18.9
2 min	15.8	21.8	19.1	12.0	15.5	17.7	18.6	17.8	21.2	18.6
4 min	16.7	24.6	21.0	13.7	16.0	19.2	19.8	19.7	23.1	21.0
Cake Volatile Solids, %										
t_f = 1 min	74.4	63.7	74.6	71.8	75.0	73.3	62.0	84.3	67.4	71.6
2 min	69.8	69.7	74.1	69.6	72.6	73.6	64.9	73.2	67.0	73.5
4 min	76.5	61.2	73.7	71.6	72.1	71.0	62.3	73.8	68.1	72.9
Cake Yield, lb/ft^2-hr										
t_f = 1 min	.30	.08	.41	.43	.19	.53	.71	.80	.59	.47
2 min	.16	.05	.14	.21	.08	.23	.44	.23	.44	.11
4 min	.05	.03	.11	.09	.04	.13	.22	.14	.22	.08

TABLE D-16

TASK D - CAKE CHARACTERISTICS, MODE II, 50% SEPTAGE/50% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	2	3	2	2
CST	25	36	54	391	78	55	28	83	38	38
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Cake Thickness, mm										
t_f = 1 min	NM	NM		NM		NM	1		2	NM
2 min	NM	NM		NM		1	2		1	NM
4 min	1	NM		NM		1	2		NM	NM
Dry Cake Weight, g										
t_f = 1 min	.22	.50	.77	1.36	.71	.88	2.39	.61	2.04	.66
2 min	.12	.50	.72	1.54	.61	1.21	3.08	.56	1.25	.68
4 min	1.78	.48	1.12	1.54	.55	1.09	3.45	.76	1.19	.85
Cake Total Solids, %										
t_f = 1 min	13.1	23.1	21.8	12.8	21.7	20.4	22.3	19.4	25.8	25.9
2 min	21.0	25.1	23.3	14.0	23.9	24.4	21.1	24.6	28.2	25.2
4 min	22.5	27.3	24.0	18.4	23.8	24.2	24.4	24.9	29.8	27.1
Cake Volatile Solids, %										
t_f = 1 min	70.9	57.0	77.7	67.7	74.7	76.1	62.8	80.3	68.1	74.2
2 min	82.7	56.7	77.2	67.5	78.7	79.3	63.0	83.9	71.2	76.5
4 min	67.2	62.4	76.2	68.8	78.2	78.9	63.5	81.6	73.1	78.8
Cake Yield, lb/ft^2-hr										
t_f = 1 min	.07	.17	.26	.45	.23	.29	.79	.20	.67	.22
2 min	.02	.08	.12	.25	.10	.20	.51	.09	.21	.11
4 min	.15	.04	.09	.13	.05	.09	.29	.06	.10	.07
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Cake Thickness, mm										
t_f = 1 min	1	NM		NM		NM	1		NM	NM
2 min	1	NM		NM		NM	1		NM	NM
4 min	1	NM		NM		NM	1		NM	NM

(continued)

TABLE D-16 (continued)

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Dry Cake Weight, g										
t_f = 1 min	1.63	.27	.95	.61	.77	1.04	2.23	.82	1.86	.81
2 min	1.61	.19	.58	1.10	.41	.69	3.76	.42	1.36	.70
4 min	1.98	.47	.44	1.28	.66	1.08	2.30	.48	1.35	.53
Cake Total Solids, %										
t_f = 1 min	12.4	17.7	17.1	10.2	17.7	14.6	19.3	18.1	21.0	19.0
2 min	16.3	21.7	17.9	10.0	18.1	19.4	27.3	15.4	23.9	20.5
4 min	22.3	22.3	20.2	13.5	18.8	22.0	23.8	20.3	25.0	23.1
Cake Volatile Solids, %										
t_f = 1 min	64.0	65.4	77.8	67.2	77.9	76.9	63.2	78.1	67.7	74.1
2 min	73.3	62.7	76.3	69.1	80.5	75.4	71.8	88.1	69.9	72.9
4 min	73.6	58.9	76.7	71.9	77.3	78.7	65.7	85.4	72.6	79.3
Cake Yield, lb/ft^2-hr										
t_f = 1 min	.54	.09	.31	.20	.25	.34	.74	.27	.62	.27
2 min	.27	.03	.10	.18	.07	.11	.62	.07	.22	.12
4 min	.16	.04	.04	.11	.05	.09	.19	.04	.11	.04

TABLE D-17

TASK D - FILTRATE CHARACTERISTICS, MODE I, TWAS ONLY

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min				6310	11640	8290	11070	3030	2700	1070
2 min				6880	14060	15130	10010	1390	1890	1120
4 min				11120	11700	8750	7950	1480	1410	1110
Filtrate Volatile Solids, mg/l										
t_f = 1 min				4050	8050	5180	6500	1970	1520	580
2 min				4320	9390	9520	6060	770	1100	570
4 min				6810	7830	5520	5110	750	720	590
Filtrate COD, mg/l										
t_f = 1 min				12250	11410	8390	8750	4660	3670	840
2 min				11240	13830	13490	9450	1840	1900	990
4 min				11090	10780	7840	6560	1500	1380	870
Filtrate pH										
t_f = 1 min				7.1	7.2	6.9	6.8	6.4	6.4	7.0
2 min				7.0	7.2	6.8	6.9	7.0	6.9	7.0
4 min				7.0	7.1	6.9	7.0	7.1	6.9	7.0
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min				6310	6820	1040	6140	1940	2040	1630
2 min				3180	10420	2020	2530	1150	1660	1120
4 min				1350	8250	1660	1840	920	1170	950
Filtrate Volatile Solids, mg/l										
t_f = 1 min				3400	5100	770	3740	1110	1150	840
2 min				1850	6940	1390	1820	540	1020	570
4 min				1010	5370	1120	1180	520	700	460
Filtrate COD, mg/l										
t_f = 1 min				11860	8050	820	5860	2140	2170	1440
2 min				5430	10160	1490	2270	1020	1530	1050
4 min				2100	8440	1410	1720	900	1050	780
Filtrate pH										
t_f = 1 min				6.9	7.4	7.2	7.1	7.5	7.0	6.9
2 min				7.2	7.4	7.1	7.3	7.3	7.4	6.9
4 min				7.4	7.4	7.1	7.7	7.1	7.4	6.9

TABLE D-18

TASK D - FILTRATE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l	140	160	140	400	100	160	180	180	180	180
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	1700	4290	2300	8340	6750	9340	6210	2130	2570	1780
2 min	1780	3360	3080	6390	6600	9730	10740	5110	3030	2100
4 min	3200	4040	3080	4960	4510	9820	7540	3820	2550	3070
Filtrate Volatile Solids, mg/l										
t_f = 1 min	880	3100	1420	5480	4200	6280	3640	1050	1430	720
2 min	870	2120	1920	4140	4140	6380	6610	2970	1760	1010
4 min	1850	2630	1760	3540	2770	6100	4640	2120	1410	2030
Filtrate COD, mg/l										
t_f = 1 min	1670	5650	2620	4300	6640	9650	5370	2540	3000	1540
2 min	1010	4080	3350	8440	5780	10190	9570	5510	3310	1870
4 min	3740	5650	3350	4920	4770	9650	6300	4260	3110	1810
Filtrate pH										
t_f = 1 min	7.5		6.9	6.8	6.9	6.8	6.9	6.5	6.8	6.5
2 min	7.8		7.0	7.1	7.1	6.8	6.7	6.5	6.5	6.5
4 min	7.8		6.9	7.2	7.3	6.9	6.8	6.4	6.5	6.5
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	2240	5380	3160	7210	4880	11460	7710	3260	2850	2310
2 min	2010	3240	2930	5450	1880	8790	3560	2730	2160	2300
4 min	1740	2860	2400	5330	3210	5730	3080	2860	1780	1860
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1260	3290	2080	5240	3330	7330	4490	1760	1550	1160
2 min	1220	2760	1630	3340	1150	5680	2300	1520	1110	1180
4 min	940	2080	1190	3230	2150	3470	1760	1590	940	820
Filtrate COD, mg/l										
t_f = 1 min	2720	6590	3380		5700	11350	6610	3830	6080	2150
2 min	1750	5730	2880	4920	3910	8260	3350	3280	2350	2140
4 min	2020	3370	3920	6950	3440	5480		3240	1960	1710
Filtrate pH										
t_f = 1 min	8.1		7.3	7.3	7.3	7.0	6.9	6.7	6.8	6.5
2 min	8.0		6.8	7.3	7.3	7.0	7.0	6.6	6.5	6.6
4 min	8.2		7.1	7.2	7.2	7.0	7.3	6.6	6.5	6.6

TABLE D-19

TASK D - FILTRATE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l		340	300	300	220	300	300	300	400	
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	1740	6460	2470	12610	5980	11890	10110	6320	2220	2280
2 min	1600	8200	2630	9270	5972	11680	8250	6040	2840	1980
4 min	1720	5080	2780	8350	4980	7430	7250	4480	2430	1900
Filtrate Volatile Solids, mg/l										
t_f = 1 min	980	4680	1340	8290	3780	7960	6340	3890	1250	1400
2 min	960	5480	1460	6040	3970	7740	5220	3850	1630	1150
4 min	1070	3260	1650	5520	3270	4810	4570	2760	1370	1060
Filtrate COD, mg/l										
t_f = 1 min	1170	8940	2540	12970	6800	12120	8640	7810	2580	2690
2 min	1250	9880	4420	9060	6800	11200	7700	6880	3350	2080
4 min	2260	6900	2880	8280	5310	7950	6770	5620	2420	1980
Filtrate pH										
t_f = 1 min	8.2		7.2	7.7	7.1	7.0	6.8	6.5	6.5	6.7
2 min	7.8		7.1	6.8	7.4	6.8	6.8	6.5	6.4	6.6
4 min	7.7		6.8	6.8	7.0	7.0	6.7	6.3	6.4	6.5
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	1790	5640	3240	8400	4820	9270	8670	5190	2470	2420
2 min	1780	3740	2600	6980	4330	3200	5070	4200	2080	2010
4 min	2180	1940	2080	4720	2430	4830	3830	3010	1660	1760
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1140	4460	1840	6000	3130	6060	5430	3370	1360	1490
2 min	1130	2910	1470	4780	3080	2140	3300	2670	1200	1100
4 min	1340	1090	1180	3170	1790	3100	2460	1930	910	980
Filtrate COD, mg/l										
t_f = 1 min	2180	7530	3420	9300	5450	9580	8480	5860	2800	2480
2 min	2100	5880	3080	6720	5060	4790	4750	3670		2120
4 min	2060	3920	2770	4610	2960	5480	3890	3790	2000	1810
Filtrate pH										
t_f = 1 min	8.1		7.3	7.1	7.0	7.4	7.0	6.5	6.5	6.5
2 min	8.0		7.0	7.3	7.5	7.3	7.2	6.7	6.7	6.6
4 min	8.0		7.1	7.5	7.6	7.2	7.4	6.6	6.5	6.6

TABLE D-20

TASK D -- FILTRATE CHARACTERISTICS, MODE I, 20% SEPTAGE/80% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH		2		3	3	2	3	3	2	
Filtration Pressure	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	1980	4150	4370	8580	6130	7784	8150	5870	3640	2690
2 min	1910	5890	3090	6800	5700	7140	8360	6020	2890	2670
4 min	1920	5200	3100	7130	5320	6110	5900	4440	2900	2460
Filtrate Volatile Solids, mg/l										
t_f = 1 min	880	2340	2360	5360	4920	4770	4980	3540	1670	1150
2 min	670	3240	1430	4340	4230	4370	5070	3530	1400	1080
4 min	760	6780	1540	4380	3540	3400	3340	2480	1460	880
Filtrate COD, mg/l										
t_f = 1 min		4710	2770	6880	7470	7950	6460	7540	3590	2250
2 min	2500	6040	3230	6720	6460	6180	6930	6720	2740	2210
4 min	2180	6280	3730	7030	5600	6100	5140	4920	2800	1920
Filtrate pH										
t_f = 1 min	7.6		5.3	7.3	7.0	6.2	7.1	5.9	5.1	5.1
2 min	5.2		5.8	7.1	7.1	6.2	6.9	6.1	5.7	5.3
4 min	5.2		5.9	7.0	6.9	5.8	6.9	6.1	5.7	5.3
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	1930	5450	3880	8490	2760	7370	7720	3380	3040	3180
2 min	2270	3880	3010	6280	4980	5420	4340	3080	2430	2830
4 min	2250	3150	2480	3490	2060	4810	4190	3210	2150	2610
Filtrate Volatile Solids, mg/l										
t_f = 1 min	740	2890	2300	5400	2620	4340	4640	1830	1520	1470
2 min	830	2050	1710	3970	3160	2970	2320	1720	1090	1270
4 min	700	1550	1130	1650	1160	2560	2240	1800	890	1040
Filtrate COD, mg/l										
t_f = 1 min	2060	6670	6270	8440	3740	6870	6150	4370	3000	2580
2 min	2180	3050	2730	5940		4790	3660	3870	2280	2400
4 min	2180	2500	2880	5550	5600	4170	3540	4100	2100	1980
Filtrate pH										
t_f = 1 min	5.2		6.0	7.3	7.1	6.0	7.4	6.1	5.8	5.3
2 min	5.3	7.4	5.8	7.3	6.9	6.2	7.3	6.3	5.8	5.3
4 min	5.3	6.4	5.8	7.3	6.9	6.0	7.5	6.0	5.8	5.3

TABLE D-21

TASK D - FILTRATE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l		160	140	400	100	160	180	180	180	180
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	3540	11850	3630	4830	6210	9760	2150	1990	1950	2260
2 min	3380	10000	3330	5570	3550	9480	3770	3500	5090	3260
4 min	3470	8840	3420	5260	2780	8480	3670	3120	5320	3580
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1900	7490	2060	2320	3920	6310	1020	800	800	990
2 min	1970	5800	1710	2700	2150	6040	1960	1760	2980	1480
4 min	1990	5180	1800	2490	1630	5440	1910	1590	3070	1740
Filtrate COD, mg/l										
t_f = 1 min	3310	13280	5310	1950	6480	11040	1710	2260	10310	2270
2 min	3230	10230	3920	4690	3980	10190	3810	3940	5920	3610
4 min	3620	9300	1490	4770	2970	9810	3740	3440	6460	3920
Filtrate pH										
t_f = 1 min	7.7	7.5	6.0	7.3	7.2	7.1	7.7	6.4	6.7	6.5
2 min	7.9	7.8	5.7	7.1	7.4	7.1	7.3	5.6	6.0	6.3
4 min	7.4	7.9	5.8	7.0	7.3	6.9	6.8	5.4	5.8	6.3
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	2710	10440	3940	7640	3810	10820	4070	3260	5750	4180
2 min	2080	6330	3690	4940	3090	6090	3580	3330	4050	4030
4 min	2640	4120	2890	4800	3250	5190	3150	3070	3710	3330
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2070	6290	2180	4320	2560	7150	2380	1670	3300	2150
2 min	1160	4290	2060	2450	1970	3820	1930	1700	2250	1810
4 min		4120	1410	2200	2030	3240	1700	1410	1890	1560
Filtrate COD, mg/l										
t_f = 1 min	4090	10390	5380	7030		11810	4360	3980	6920	4610
2 min	4280	6720	4960	4140	4530	7800	3740	3590		4650
4 min	4090	7190	3540	4140	3440	6330	3270	3160	4770	3540
Filtrate pH										
t_f = 1 min	7.6		6.2	7.1	7.2	7.1	7.4	5.6	5.7	6.3
2 min	7.6		6.0	7.1	6.6	7.1	7.6	5.6	5.7	6.3
4 min	7.7		5.7	7.0	7.1	7.2	7.4	5.6	5.6	6.2

TABLE D-22

TASK D - FILTRATE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l		340	300	300	220	300	300	300	400	
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	3180	16060	3930	6960	4340	7580	4110	4690	7440	4160
2 min	4560	12430	4480	4660	2690	9930	4180	5780	4680	3980
4 min	3630	14550	3660	4090	4160	7320	3990	5560	3780	4340
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1900	10480	2436	4430	3050	5000	2430	2990	4430	2560
2 min	3040	7690	2990	3330	1720	6620	2583	3840	2940	2400
4 min	2400	9160	2200	2720	2740	4870	2340	3610	2430	2410
Filtrate COD, mg/l										
t_f = 1 min	3620	17580	3450	7500	4840	9420	4360	6560	9230	4920
2 min	6110	13520	5770	5160	4670	11430	4750	6480	5610	5040
4 min	4980	14920	4610	4770	4820	8490	4440	6560	5390	5620
Filtrate pH										
t_f = 1 min	7.5	7.8	6.3	7.1	6.9	7.0	7.2	5.8	5.6	6.3
2 min	6.3	7.7	6.3	7.3	7.0	6.8	7.0	5.9	5.7	6.4
4 min	7.1	7.5	5.9	7.0	7.1	7.0	7.0	5.8	5.5	6.4
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	3440	15450	5070	4390	5430	9730	5000	5410	4290	5300
2 min	5000	10380	4950	4810	4560	6540	3950	5030	3850	4760
4 min	5070	8550	3730	4840	3470	6290	3560	3470	3280	3780
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2540	9810	3470	3060	4110	6450	3040	3680	2830	3620
2 min	3060	6430	3570	3460	3260	4770	2230	3370	2170	3340
4 min	3220	5770	2320	3860	2740	4290	2130	2450	1990	2440
Filtrate COD, mg/l										
t_f = 1 min		16330	6920	5160	6540	10500	5760	7190	5000	6540
2 min	6150	11800	6350	6020	5370	7880	4590	6010	4920	5850
4 min	5600	8980	4850	5940	4280	7100	3660	5000	4310	5190
Filtrate pH										
t_f = 1 min			6.0	7.3	7.0	7.1	6.9	5.8	5.6	6.4
2 min	7.4	7.8	6.4	7.1	6.9	7.1	7.0	5.8	5.6	6.4
4 min	7.2	7.8	5.6	7.0	7.1	7.1	7.4	5.8	5.5	6.4

TABLE D-23

TASK D - FILTRATE CHARACTERISTICS, MODE I, 50% SEPTAGE/50% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH		2	3	3	3	2	3	3	2	
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	3528	13670	4970	7620	5250	7540	3790	7180	8220	4830
2 min	3450	14810	4570	5650	5140	8520	4300	8050	5410	5460
4 min	3590	12260	3940	6120	5220	7250	4140	7580	5010	5810
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1380	8235	2910	4730	3220	4020	1870	4450	4570	2160
2 min	1250	8920	2570	3460	3170	4520	2260	5080	2670	2690
4 min	1340	6990	2130	3320	3260	3670	2200	4740	2460	2840
Filtrate COD, mg/l										
t_f = 1 min	4440	15310	6350	6410	7080	6640	3890	10000	8690	4540
2 min	4090	16410	5960	6800	6690	7720	5140	11020	5350	5080
4 min	3930	12730	4730	5620	6690	5870	4120	9140	4960	5230
Filtrate pH										
t_f = 1 min	4.4	7.2	4.9	6.6	4.0	5.0	7.0	4.7	4.9	4.6
2 min	4.4	6.5	5.0	6.7	3.7	4.7	6.7	5.1	4.8	4.4
4 min	4.4	6.8	5.1	6.1	5.9	4.7	6.5	5.2	4.8	4.4
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	4920	15840	6160	7940	6200	10100	4310	8750	5410	7210
2 min	4100	10220	4840	7120	5190	7050	3720	8130	4870	6240
4 min	4180	7010	4530	6480	3910	5750	3560	6440	4640	5300
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2460	9360	3830	4960	4650	5810	2540	5730	2630	4000
2 min	1580	5640	2820	4260	3500	3550	2070	5250	2290	3370
4 min	1580	3940	2600	3770	2400	3250	1900	3790	2060	2650
Filtrate COD, mg/l										
t_f = 1 min	6460	13750	7580	7970	8020	9960	4120	10710	5880	7230
2 min	4480	9450	6270	7420	6380	5710	3970	9450	2960	6270
4 min	4320	9060	5150		4670	4015	3420	7580	4500	4920
Filtrate pH										
t_f = 1 min	4.4	6.3	5.1	6.2	6.3	4.8	6.7	5.2	4.8	4.4
2 min	4.4	6.7	5.1	5.9	6.0	4.6	6.8	5.2	4.8	4.3
4 min	4.4	6.8	5.1	6.2	6.2	4.6	6.6	5.2	4.8	4.3

TABLE D-24

TASK D - FILTRATE CHARACTERISTICS, MODE II, 20% SEPTAGE/80% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l		160	140	400	100	160	180	180	180	180
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	3110	4150	4580	16440	6910	8820	2990	3050	3630	2890
2 min	3240	5980	5340	17780	6318	3970	4130	4760	4620	3120
4 min	3120	5140	4920	15540	5790	6580	4540	3750	5880	3180
Filtrate Volatile Solids, mg/l										
t_f = 1 min	940	1880	2280	10610	4170	5220	1110	1100	1480	850
2 min	1190	3060	2702	11700	3750	1530	1640	2080	2040	860
4 min	1240	2520	2400	10170	3340	3350	1920	1370	2850	960
Filtrate COD, mg/l										
t_f = 1 min	2930	4920	4920	15910	5730	8390	1630	2520	1750	1800
2 min	3680	7150	5630	17800	5420	3370	3390	3990	2490	1910
4 min	3760	5380	5238	15910	4770	5330	3040	2910	3700	1990
Filtrate pH										
t_f = 1 min	5.5	5.9	5.8	6.9	6.8	6.3	5.5	5.1	5.1	5.2
2 min	5.8	5.5	5.6	7.5	6.8	6.8	5.2	5.0	5.1	5.1
4 min	5.9	5.5	5.6	7.0	6.7	6.0	5.1	5.0	5.1	5.1
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	3640	5010	4800	14690	6140	6800	5650	3700	5060	3250
2 min	3330	4180	3870	12130	5050		4430	3750	5510	3420
4 min	3080	4150	3730	9720	4290	3430	3420	3590	4300	3210
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1520	2480	2440	9770	3680	3330	2640	1330	2370	970
2 min	1380	1720	1700	7900	3050		2670	1360	2950	1100
4 min	1190	1770	1700	6680	2480	1210	1170	1170	1780	930
Filtrate COD, mg/l										
t_f = 1 min	3950	5610	4590	13070	4880	6510	4670	2870	2410	2270
2 min	3300	4770	3330	12910	4110	3210	3070	2910	2330	2150
4 min	3300	3770	3690	11020	3600	2740	2140	2710	1870	2150
Filtrate pH										
t_f = 1 min	5.8	5.8	7.2	7.2	6.8	6.6	5.2	5.0	5.1	5.1
2 min	5.8	5.6	6.4	7.6	7.2	6.4	5.1	5.0	5.1	5.1
4 min	5.8	5.5	6.5	7.4	7.2	6.5	5.1	5.0	5.1	5.1

TABLE D-25

TASK D - FILTRATE CHARACTERISTICS, MODE II, 20% SEPTAGE/80% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l		340	300	300	220	300	300	300	400	340
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	3100	10940	5920	14760	6650	7580	4310	5190	4610	11280
2 min	3210	8430	5800	15530	6300	6080	5140	4990	4300	10910
4 min	2910	7660	5280	13370	6030	5890	3850	4030	4290	7840
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1630	7020	3560	9710	4100	4510	2340	2870	2270	7280
2 min	1940	5360	3860	10160	3990	3570	2710	2740	2250	7500
4 min	1600	4750	3360	8910	3900	3280	2070	2010	4210	5220
Filtrate COD, mg/l										
t_f = 1 min	3910	10000	6310	16060	6130	7300	3620	4460	2180	12190
2 min	4030	8620	6080	17010	6320	5960	4280	4230	2530	12420
4 min	3990	7920	5250	13700	5610	6040	2920	3720	2490	9610
Filtrate pH										
t_f = 1 min	5.9	5.8	6.1	7.4	6.9	6.2	5.4	5.3	4.7	6.3
2 min	5.9	5.7	6.0	7.4	6.6	6.4	5.5	5.4	5.1	6.3
4 min	5.9	5.7	6.0	6.7	6.6	6.4	5.5	5.4	5.1	6.4
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	3330	6050	5540	12750	5340	5780	6120	3890	5080	6810
2 min	2820	4600	4410	11650	5020	4340	4230	2700	4680	4050
4 min	2490	4420	3690	10060	4220	4700	3770	3170	4260	3280
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1840	3500	3360	8450	3430	3630	3480	2140	2890	4730
2 min	1480	2990	2500	7690	3480	2100	2370	1060	2530	2810
4 min	1240	2560	2230	6680	2810	2580	1830	1320	2170	2220
Filtrate COD, mg/l										
t_f = 1 min	4500	4770	5330	12600	4620	5330	5290	4070	2570	5700
2 min	3600	4310	4310	12130	4110	5410	3270	2170	2140	8590
4 min	2980	4690	3370	10390	3870	4550	2920	3260	1830	4380
Filtrate pH										
t_f = 1 min	5.9	5.9	6.4	7.4	7.2	6.4	5.7	5.4	5.1	6.6
2 min	5.9	5.8	6.0	7.4	6.5	6.4	5.6	5.3	5.1	6.7
4 min	5.9	5.8	6.3	7.6	7.0	6.3	5.6	5.4	5.1	6.8

TABLE D-26

TASK D - FILTRATE CHARACTERISTICS, MODE II, 20% SEPTAGE/80% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH	2	2	3	3	3	2	3	3	2	2
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	8520	7890	6100	17620	6030	10890	7000	7580	9280	10440
2 min	10500	8000	5040	16590	5740	20340	5650	6710	15240	10590
4 min	10370	8170	6240	13280	5230	18930	5590	6630	10180	11260
Filtrate Volatile Solids, mg/l										
t_f = 1 min	3300		2980	11540	3240	4030	3410	3980	3980	4840
2 min	3750	2900	2840	10800	2920	10260	2400	3340	8050	4730
4 min	3450	3030	3140	8670	2860	8900	2360	3280	4350	5250
Filtrate COD, mg/l										
t_f = 1 min	3060	3620	5210	17950	4770	6270	5140	6400	22880	8360
2 min	3150	3920	4820	17640	3610	12940	3660	5500	17280	6250
4 min	2990	4310	5570	15430	3420	11760	3660	5000	16970	7270
Filtrate pH										
t_f = 1 min	3.2	3.2	4.6	7.3	5.7	3.5	4.4	4.2	2.2	3.3
2 min	3.2	3.0	4.2	7.4	4.8	3.0	4.1	4.1	2.1	3.1
4 min	3.3	3.0	4.2	6.9	4.8	2.9	4.1	4.0	2.1	3.0
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	10680	8190	6580	12820	5060	18970	6180	7060	10990	9100
2 min	10730	8040	5250	11580	4910	16660	5960	4980	11430	9440
4 min	10590	7960	5050	10400	4490	15830	5500	4830	11310	8730
Filtrate Volatile Solids, mg/l										
t_f = 1 min	3940	3420	3420	8420	2480	9320	2870	3420	4930	4060
2 min	3880	2850	2462	7810	2400	7220	2550	2130	5250	4040
4 min	3660	2670	2130	6990	2020	6980	2400	2090	5230	3380
Filtrate COD, mg/l										
t_f = 1 min	4610	3690	5650	13390	3380	10350	4120	5350	14010	5310
2 min	3190	3460	4280	10550	3080	8390	3970	3490	13540	4840
4 min	3270	12920	4240	12600	3080	6820	3310	3570	15100	3980
Filtrate pH										
t_f = 1 min	3.1	3.0	4.2	7.2	5.4	2.9	4.1	4.0	2.1	3.0
2 min	3.2	3.0	4.2	7.4	4.9	2.9	4.1	4.0	2.1	3.0
4 min	3.3	3.0	4.2	7.4	4.7	3.0	4.1	4.0	2.1	3.0

TABLE D-27

TASK D - FILTRATE CHARACTERISTICS, MODE II, 50% SEPTAGE/50% TWAS, ALUM TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)	Al(III)
Chemical Dosage, mg/l	140	160	140	400	100	160	180	180	180	180
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	3240	18590	5570	10790	4970	7840	3940	5580	2600	7230
2 min	3720	21180	5440	11470	4820	5750	4520	5690	3350	8360
4 min	3540	21510	4810	10950	4850	6100	4630	4790	4550	8410
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1330	11010	3050	7420	2870	4660	1050	2870	630	1910
2 min	1540	12250	1000	5880	2740	2740	1290	2800	1060	2250
4 min	1480	12400	2440	7500	2810	2960	1360	2300	1820	2320
Filtrate COD, mg/l										
t_f = 1 min	3990	20550	6830	14020	4580		1440	6280	3350	2420
2 min	4500	22290	6670	14470	4310	5100	1790	6200	4630	2660
4 min	4460	17710	5560	13850	4350	5650	1670	4650	5840	2850
Filtrate pH										
t_f = 1 min	5.6	5.5	5.2	7.5	6.8		4.2	4.7	5.0	3.7
2 min	5.3	5.6	5.1	7.2	6.7	7.0	4.2	4.7	4.8	3.8
4 min	5.3	5.6	5.1	7.3	6.8	7.0	4.2	4.7	4.9	3.8
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	4010	15830	5100	10970	4320	7450	4790	7130	3530	8690
2 min	4050	15320	4460	9600	4840	4380	4860	4970	3170	8060
4 min	4070	15550	4090	7600	4870	4940	4540	4780	2840	7950
Filtrate Volatile Solids, mg/l										
t_f = 1 min	1780	9380	2650	7550	2480	3910	1440	3930	1130	2480
2 min	1900	9090	2110	6510	2830	1970	1520	2370	840	2090
4 min	1800	3140	2010	5260	2960	2270	1330	2260	680	1970
Filtrate COD, mg/l										
t_f = 1 min	4920	22130	5870	13540	3960		2060	6860	5100	3160
2 min	5310	17550	5480	11650	4420	3690	2060	4340	4360	2620
4 min	5270	18020	5240	9610	4460	4080	1750	4380	3970	2460
Filtrate pH										
t_f = 1 min	5.4	5.8	5.2	7.6	6.9		4.2	4.7	4.9	3.8
2 min	5.6	5.8	5.1	7.6	7.0	7.2	4.2	4.7	4.9	3.8
4 min	5.3	5.8	5.1	7.6	6.8	7.4	4.2	4.7	4.9	3.8

TABLE D-28

TASK D - FILTRATE CHARACTERISTICS, MODE II, 50% SEPTAGE/50% TWAS, FERRIC CHLORIDE TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Coagulant Used	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)	Fe(III)
Chemical Dosage, mg/l	260	300	300	300	220	300	300	300	400	340
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	4490	23040	5770	13280	6190	5680	3610	4410	3040	3970
2 min	5940	22640	5210	11060	5520	7250	3890	4730	3360	4850
4 min	5160	21980	5440	12460	5840	6720	3910	5600	3260	3590
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2630	13660	3520	8870	3990		1890	2330	890	2730
2 min	3780	13750	3150	7460	3570	4500	2050	2510	1490	2820
4 min	3240	13280	3410	8420	4090	4070	2000	3370	1430	1770
Filtrate COD, mg/l										
t_f = 1 min	5970	24190	6670	16380	5770	5960	2610	5390	4630	3750
2 min	8020	24030	7380	13390	5380	7840	3110	5540	3930	4650
4 min	6940	23560	6830	15280	5880	6980	2920	6320	3580	2520
Filtrate pH										
t_f = 1 min	5.8	5.6	5.3	7.4	6.3	7.0	5.1	5.0	4.9	4.8
2 min	5.6	5.7	5.3	7.7	6.2	6.5	5.5	5.1	4.9	5.3
4 min	5.6	5.7	5.3	7.5	6.4	6.5	5.5	5.1	4.9	5.4
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	4670	16500	5390	10770	6430	8490	4320	4450	3110	3870
2 min	4780	16610	5620	9560	5740	6660	4500	4340	2960	3930
4 min	5270	15770	4630	9840	5390	5770	3530	3710	2780	3550
Filtrate Volatile Solids, mg/l										
t_f = 1 min	2820	10620	3260	7190	4290	5420	2350	2380	1060	1980
2 min	2930	10470	3760	6250	3800	4170	2410	2320	1020	2140
4 min	3340	9930	2910	6480	3530	3430	1820	1960	1130	1760
Filtrate COD, mg/l										
t_f = 1 min	6860	19920	7380	13700	5920	9020	2920	4690	4510	3910
2 min	6320	19760	7300	12760	5270	6900	3740	4540	4320	4060
4 min	7520	17710	5710	13070	4920	6350	2800	3800	3540	3480
Filtrate pH										
t_f = 1 min	6.5	5.8	5.4	7.5	6.6	6.8	5.7	5.1	4.9	5.4
2 min	6.0	5.7	5.3	7.5	6.6	6.9	5.8	5.1	4.9	5.4
4 min	5.9	5.9	5.2	7.4	6.6	6.8	5.7	5.1	4.9	5.4

TABLE D-29

TASK D - FILTRATE CHARACTERISTICS, MODE II, 50% SEPTAGE/50% TWAS, ACID TREATMENT

SAMPLE NO.	0127	0228	0403	0511	0521	0529	0601	0608	0615	0622
Chemical Used	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4	H_2SO_4
pH		2	3	3	3	2	3	3	2	2
Filtration Pressure, lb/in^2	15	15	15	15	15	15	15	15	15	15
Filtrate Total Solids, mg/l										
t_f = 1 min	8810	13620	6520	14100	5680	14900	5410	15070	42860	11770
2 min	4110	13680	6640	12500	6210	15820	6320	13590	44820	10160
4 min	7530	14190	5990	10840	5790	14420	5380	11930	40240	9090
Filtrate Volatile Solids, mg/l										
t_f = 1 min	4320	6650	3400	9670	3350	7630	2320	9850	22070	6740
2 min	2390	6850	3570	8460	3680	8260	2810	8740	22890	5430
4 min	3020	7440	3160	7350	3360	7010	2280	7440	19170	4620
Filtrate COD, mg/l										
t_f = 1 min	8950	12110	8810	18110	5270	9020	3740	17990	6460	9690
2 min	10950	11540	8330	14800	3770	9290	4090	14880	12140	7340
4 min	4570	12490	7540	11970	5150	8860	3190	15350	7000	6210
Filtrate pH										
t_f = 1 min		3.5	4.4	7.3	5.6	3.3	4.3	4.4	3.1	3.1
2 min		3.2	4.3	7.6	4.7	3.1	4.1	4.3	3.0	3.0
4 min	3.4	3.1	4.2	7.7	4.7	3.1	4.1	4.3	3.0	3.0
Filtration Pressure, lb/in^2	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Filtrate Total Solids, mg/l										
t_f = 1 min	7980	13980	5920	12760	5930	14340	6880	9430	38390	8760
2 min	7460	14660	6700	11510	5970	13940	5230	9920	36870	8280
4 min	7650	4640	6060	10500	5180	12860	5180	9180	38850	7640
Filtrate Volatile Solids, mg/l										
t_f = 1 min	3520	7510	2920	8520	3470	6740	3190	5800	16910	4500
2 min	3020	7680	3550	7820	3430	6630	2110	6190	15470	3990
4 min	2920	4580	3040	7210	2870	5840	2050	5640	16640	3570
Filtrate COD, mg/l										
t_f = 1 min	5830	13120	8330	15280	5000	9020	4780	10080	7630	5980
2 min	4490	12020	9680	13390	5290	6470	3190	10700	9110	5700
4 min	3820	9010	7620	14490	4460	8510	3230	10230	7080	4880
Filtrate pH										
t_f = 1 min	3.4	3.1	4.2	7.6	5.4	3.1	4.0	4.3	3.0	3.0
2 min	3.4	3.1	4.2	7.5	5.2	3.1	4.0	4.3	3.0	3.0
4 min	3.4	3.1	4.2	7.7	5.2	3.0	4.0	4.3	3.0	3.0

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-80-112 .2	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE MONITORING SEPTAGE ADDITION TO WASTEWATER TREATMENT PLANTS Volume II. Vacuum Filtration of Septage		5. REPORT DATE August 1980 (Issuing Date) 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Charles R. Ott and Burton A. Segall		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Lowell Department of Civil Engineering One University Avenue Lowell, Massachusetts 01854		10. PROGRAM ELEMENT NO. 35B1C 11. CONTRACT/GRANT NO. Grant No. R805406010
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin.,OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Final Vol. II 1/78-12/79 14. SPONSORING AGENCY CODE EPA/600/14

15. SUPPLEMENTARY NOTES

See also Volume I (EPA-600/2-79-132, NTIS PB80-143613)
Project Officer: Steven W. Hathaway (513) 684-7615

16. ABSTRACT

The study examined the feasibility of using conventional vacuum filtration to dewater conditioned septage sludge, alone and in combination with thickened waste activated sludge. The septage was conditioned with aluminum sulfate, ferric chloride, and sulfuric acid, each used independently. Lab experiments were conducted with a filter leaf apparatus that simulates a coil spring vacuum filter. The capillary suction test, CST, was used to estimate filterability. Field studies, utilizing a full-scale vacuum filter and large quantities of septage, were conducted at the Medfield, Massachusetts wastewater treatment plant. The studies showed that vacuum filtration of a combined mixture of the thickened waste activated sludge and septage conditioned with either alum, ferric chloride, or acid is feasible. Excellent cake yields and filtrate quality were obtained. The cost of treating septage in the solids handling train at Medfield was less than the cost of adding septage to the liquid stream at the plant inlet.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Waste Treatment Sludge Disposal Dewatering Septic Tanks	Septic Tank Sludge Septage Treatment Vacuum Filtration	13B

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES 156
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

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