# DRY ANAEROBIC DIGESTION OF MUNICIPAL SOLID WASTE

A Thesis

Presented to the Faculty of Graduate Studies

of the University of Manitoba

in Partial Fulfilment for the

Degree of Master of Science

by

Dennis Mark Heinrichs

August 1990

ISBN 0-315-71902-8

DRY ANAEROBIC DIGESTION OF MUNICIPAL SOLID WASTE

BY

DENNIS MARK HEINRICHS

A thesis submitted to the Faculty of Graduate Studies of
the University of Manitoba in partial fulfillment of the requirements
of the degree of

MASTER OF SCIENCE

**ABSTRACT**

Anaerobic digestion of municipal solid waste enriched with waste secondary sludge has been accomplished at solids concentrations of 20 to 40%. By utilizing the waste near its original solids level, handling and water requirements were minimized. Valuable end-products of methane and compost were obtained.

Experimental work involved the anaerobic digestion of a synthetic municipal solid waste (MSW), made using high newsprint content and food waste, supplemented with waste sewage sludge (WSS). The responses measured were biogas productivity, percent methane, total solids and volatile solids, alkalinity, pH, and volatile fatty acid concentration. This study was undertaken to determine the optimum temperature, solids level, and MSW:WSS ratio for a high paper content North American waste and to gain a further understanding of the effects of various operational variables.

Dry anaerobic digestion was successful at solids levels beyond 20%. Optimum biogas production rates were realized in thermophilic digesters. Mesophilic digesters with same operating parameters, were more stable in operation but yielded 30% less biogas. Optimum operating parameters found in this study were solids concentration of 30 to 35%, longer retention time of 21 days, and a MSW:WSS ratio of one.

## TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

**TABLE OF CONTENTS** (continued)

## LIST OF TABLES

## LIST OF FIGURES

**LIST OF FIGURES** (continued)

**ACKNOWLEDGEMENTS**

It is appropriate at this time to extend special thanks to several individuals who helped make this thesis a reality:

-the staff of the Environmental Engineering Division: Dr. Jan Oleszkiewicz for his direction, encouragement and advice; Dr. Art Sparling for his participation on the Thesis Review Committee and his practical advice along the way; Mrs. Judy Tingley for her assistance in analysis, and support in the lab; and to the Civil Engineering technicians and craftsman who helped build the necessary equipment.

- Dr. Stefan Cenkowski of Agricultural Engineering, for serving on the Thesis Review Committee.

- a sincere and special thankyou is extended to my fellow research colleague Mr. Hector Poggi-Viraldo, who without his experience, keen interest, and long hours, this research would still be on-going. In addition thanks to: Paul Barsalou and Thomas Marstaller who kept me company in the lab throughout the summer; Dave Woytowich for his attention to detail; and Daryl McCartney for his practical encouragement.

- finally, my family, especially Dad and Mom, who were always willing to support me in whatever way necessary.

## 1.0 INTRODUCTION

Energy can be recovered from municipal solid waste (MSW) through either incineration or methane collection resulting from anaerobic decomposition (Chynoweth and Legrand, 1988). Generation of methane has been accelerated through leachate recycle in landfills (in-situ recovery) or through batch anaerobic digestion, at various total solids (TS) levels (Ten Brummeler et al., 1988; Kasali and Senior, 1989).

High solids anaerobic digestion has been achieved at total solids concentrations above 20%. Most municipal solid waste generated has a solids content near 40% TS (Ali Khan and Burney, 1989). By utilizing the waste near its original solids level, handling and water requirements are minimized. Dry anaerobic digestion (DAD) reduces volumes to be processed and may eliminate liquid effluent. DAD produces valuable end-products of methane and compost (Wujcik, 1980).

One of the demonstrated ways of increasing the rate of digestion has been co-digestion of MSW with waste secondary sludge (Six and DeBaere, 1988). Other methods investigated included increasing digestion temperature, lowering solids concentration, increasing nutrient supply as well as other process variations (Pfeffer, 1973; Cecchi et al., 1988; Graindorge et al., 1989).

The effects of variations in temperature, solids concentration, sludge content, along with other operational variables such as waste composition have not been well documented. Several European continuous-feed high solids anaerobic digesters are at the pilot plant stage, with one on a commercial level. Little information on high solids anaerobic digestion has been gained from these plants due to their commercial nature.

The MSW found in North America has a much higher paper content in comparison to European urban waste (Graindorge et al., 1989). The MSW in this study was a synthetic waste, made up of newsprint and food waste, supplemented with waste secondary sludge (WSS).

The goal of this study was to determine the optimum operational parameters for a high newspaper content municipal solid waste supplemented with waste secondary sludge. Operational variables considered were:

- temperature
- solids concentration
- MSW:WSS ratio and
- mass retention time.

Performance indicators used were:

- biogas productivity
- biogas composition
- removal efficiency
- VFA concentration
- pH and
- alkalinity.

## 2.0 LITERATURE REVIEW

The following literature study is intended to cover the operational parameters important to the in-vessel anaerobic digestion of high solids, particularly as it relates to MSW and waste sludge degradation. Municipal solid waste composition and end-product use are presented. Anaerobic digestion in landfills and batch in-vessel digestion are also covered to a lesser degree. The discussion does not intend to describe anaerobic digestion in general. This topic has been well covered by many others (Parkin and Owen, 1986; Pfeffer, 1979). Table 1 gives a comparison of results from both continuous and batch studies.

### 2.1 Effect of Solids Concentration

The effect of solids concentration on substrate degradation has been reported to be significant. In sludge digestion, an increase in total solids decreases process efficiency. In high solids digestion of manure substrate mixtures, methane production decreased considerably between 30 and 35% TS (Wujcik and Jewell, 1988). Graindorge et al. (1989) digested MSW with high levels (40%) of paper and cardboard, they found that due to the rheology of the digestate a solids concentration of 25% should not be exceeded. Present Valorga operating solids level was reported to be 35% TS for a highly fermentable organic waste.

| SUBSTRATE | Fermentable OMSW | Fermentable Precomposted OMSW | Fermentable OMSW+paper & cardboard | North American MSW+WSS | North American MSW+WSS | Dairy Manure | Dairy Manure | Wheat Straw, Dairy Manure and Water | Wheat Straw, Dairy Manure and Water | compost/MSW 1/4, with seed sludge | 30% cardboard 30% newsprint 20% magazine 10% kitchen paper 10% white paper |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MRT, day | 14 | 21 | 17 | 21 | 21 | 22 | 15 | 20 | 10 | batch | batch |
| TS feed % | 34-40 | 32-36 | 30 | 35 | 35 | 20.4 | 20.4 | 25 | 25 | 35 | 30 |
| Lignin, % of TS | N/A | N/A | 10 | 17 | 17 | 15.5 | 15.5 | N/A | N/A | 5.6 | 11 |
| Temp. C | 35 | 35 | 40 | 39 | 53 | 35 | 35 | 35 | 35 | 30 | 40 |
| Loading Rate kg VS/m3*d | 12.9 | 11 | 6.6 | 4.82 | 4.9 | 7.5 | 11.6 | 7.86 | 15.7 | batch | batch |
| Removal Efficiency % VS basis | 41^ | 64^ | 42 | 49.6 | 62 | 29.5 | 23.3 | 28.3 | 8.5 | 55 | 65 |
| Biogas Prodtivity m3 BG/m3 wv*d | 3.8^ | 5.1^ | 2.18^ | 1.72 | 2.17 | 1.6 | 2.1 | 1.6 | 0.96 | batch | batch |
| Biogas Yield m3 BG/kg VS rem. | N/A | N/A | 0.786^ | 0.72^ | 0.72^ | 0.70^ | 0.73 | 0.72^ | 0.72^ | 0.78 | 0.815 |
| Biogas Pseudo-Yield m3 BG/kg VS fed | 0.295^ | 0.464^ | 0.33 | 0.357 | 0.444 | 0.20^ | 0.17^ | 0.20^ | 0.06^ | 0.429^ | 0.53^ |
| Reference | (DeBaere et al., 1985) | | (Graindorge et al.,1989) | (Poggi-Viraldo et al., 1990; present work) | | (Hills (1), 1980) | | (Wujcik, 1980) | | (Graindorge et al.,1989) | (Ten Brummeler et al., 1988) |

N/A - not available

^ - estimated

Table 1: Comparison of Results of Various Anaerobic High Solids Studies

Researchers using the Dranco process have been operating at a total solids level of 30 to 35%, digesting a highly fermentable organic MSW (OMSW) (DeBaere et al., 1985). Research to date indicates that digestion of highly fermentable OMSW is most feasible in the range of 30 to 35% TS. Higher paper content wastes have not been examined in detail.

## 2.2 Effect of Temperature

In the batch digestion of OMSW, temperature was found "to exert significant effects on the interrelated metabolic processes of acidogenesis, solventogenesis, and methanogenesis" (Kasali and Senior, 1989). At 40% TS, thermophilic temperatures (55 $^{o}$C) proved inhibitory to biogas production and there was an accumulation of solvents. A bactericidal effect was observed to occur on the methanogens at the 55 $^{o}$C incubation temperature. It was concluded that optimal rates of methanogenesis can be maintained only at mesophilic temperatures.

Debaere et al. (1985) observed both mesophilic and thermophilic OMSW digesters, producing similarly 6.2 $m^3/m^3r*d$ at loadings of 14.3 to 17.2 kg COD/$m^3$*d, using a highly fermentable OMSW. At a higher loading rate, of 18.6 kg COD/$m^3$*d mesophilic gas production decreased by about 10%. With a higher COD loading of 21.4 kg/$m^3$*d the thermophilic digestion rate increased to 8.5 $m^3$ biogas/$m^3$r*d. At the total solids content of 30 to 35%, the thermophilic digester was capable of operating at a loading rate 25% above the maximum mesophilic loading rate.

Using landfilled MSW with 39 to 57% TS, optimum operating temperatures reported by other researchers have been 41 °C (Hartz et al.,1982) and 42 °C (Mata-Alverez and Martinez-Virturtia, 1986 in Kasali and Senior, 1989).

At a long retention time of 30 days, Pfeffer (1973) found thermophilic digestion in slurries (4 to 10% TS) to be 60% more efficient than mesophilic. Using landfill slurries (greater than 5% TS), 50% greater gas production rates were reported for a 30 day retention time at thermophilic temperatures compared to mesophilic (Cooney and Wise, 1975 in Kasali and Senior, 1989). Using piggery and dairy wastes (3-18% TS), performance of thermophilic digesters was more efficient with increasing loading conditions. At a retention time of 6 days, 30% more gas production was realized at thermophilic than mesophilic temperatures (Kimchie et al., 1988).

Seemingly contradictory to the above findings, Buivid et al. (1981) demonstrated the importance of temperature and the initial methanogenic population by adding digested sewage sludge to refuse. In the presence of a 10% (w/w) inoculum, the total volume of the methane evolved was higher at 60 °C than 37 °C. When the inoculum was reduced to 5% (w/w), there were reductions in methanogenesis such that only 2% of the methane generated at 37 °C was produced at 60 °C.

Thermophilic operating temperatures appear to result in higher removals and efficiencies. Other researchers report operational difficulties in the thermophilic range. The effect of temperature, although present, is not definitive.

## 2.3 Effect of Retention Time/Loading Rate

In the digestion of barley straw and dairy manure at an average total solids of 13%, 35 °C, methane production was reported to be 1.27 to 2.46 $m^3/m^3r*d$, at loading rates of 5.2 to 12.5 kg VS/$m^3$*d respectively. Efficiency was reported to be fairly constant for retention times (RT) greater than 20 days but dropped off considerably for retention times less than 15 days. With a decrease in retention time from 25 to 10 days the same researcher observed a decrease in methane content from 62.5% to 57.4% (Hills, 1980a).

Other researchers, using a 6% TS slurry of OMSW with primary sludge (PS) or WSS, found that the best results from an economical and processing point of view were obtained at a retention time of 14 to 15 days. Below this point there was a wash-out of bacteria. Beyond two weeks biogas remained relatively constant indicating 15 days as the most economical retention time (Cecchi et al., 1988).

In another study, an increase in retention time from 17 to 25 days did not significantly improve conversion of organic matter. An increase in conversion from 51% to 56% was reported. For OMSW containing 42% paper and cardboard, a 17 d RT with 25% TS was recommended (Graindorge et al., 1989).

Using a systems analysis approach, Chynoweth and Legrand (1988) determined the optimum economical retention time for high solids anaerobic digestion to exist near 3 weeks. Researchers report that optimum MRT may vary from 15 to 25 days depending on temperature, solids concentration and substrate.

## 2.4 Effect of pH and VFA

Most researchers found that it was necessary to provide buffering to high solids digestion, suggesting higher rates in hydrolysis and acidogenesis. Methanogenic populations have been seen as the rate limiting step. Mao and Pohland (1973) found that in sludge-seeded studies, methanogenic bacteria were soon outnumbered by acidogenic species, due to their sensitivity to oxygen and their lower specific growth rates.

Calcium carbonate was not effective in buffering (Ten Brummeler et al., 1988). Jewell et al. (1981) found $CaCO_3$ did not control pH sufficiently. Sodium bicarbonate gave best results. The initial buffer/substrate solids ratio was 0.06. The actual $Na^+$ concentration during the study was 8.9 g/L, which exceeded reported toxicity levels for methanogens (Duarte and Anderson, 1982 in Ten Brummeler et al., 1988). In batch studies using hand-sorted landfill refuse at 40% TS, 2.5% (w/v), sodium bicarbonate was shown to promote fermentation. A lower concentration near 1% is speculated to be more cost effective in conjunction with the optimization of different variables such as refuse density, moisture content, pH or temperature (Kasali et al., 1989a).

DeBaere and his colleagues found volatile fatty acids were inhibitory to the hydrolysis phase at relatively low concentrations so that only a maximum of 20-30 g/L were produced in the form of volatile acids and lactic acid. The pH at this point was reported to be low, between 5.5 and 7.0. Above this concentration of organic acids, hydrolysis was reported to cease (DeBaere et al., 1985).

In the operation of dry anaerobic digesters buffering has been recommended to maintain pH near neutral. Volatile fatty acid concentration has shown to become inhibitory if allowed to accumulate.

## 2.5 Effect of Digestate Composition

The composition of urban municipal solid waste can greatly affect the performance of digestion. Table 2 gives a breakdown of the typical wastes from European and North American cities. Paper and cardboard make up 45% of Canadian urban waste. European urban waste contains a greater percentage of highly fermentable organics and less paper.

| | EUROPE | | | NORTH AMERICA | |
|---|---|---|---|---|---|
| | (F) | (FRG) | (UK) | (U.S.A.) | (CAN.) |
| Paper and Cardboard | 30 | 20 | 33.9 | 37.1 | 45 |
| Biodegradable | 25 | 42.3 | 23.4 | 26 | 26 |
| Fines | 17 | 11.5 | 7.1 | -- | 1 |
| Inerts (total) | 19 | 23.1 | 25.7 | 28.4 | 20.4 |
| Glass | 8 | 11.6 | 14.4 | 9.7 | 6.5 |
| Metals | 6 | 3.9 | 7.1 | 9.6 | 6.4 |
| Plastics | 5 | 7.6 | 4.2 | 7.2 | 5.7 |
| Miscellaneous | 9 | 3.1 | 9.9 | 8.5 | 7.8 |

(per cent weight)

(Bonomo and Higginson, 1988)

Table 2: Urban Refuse Composition Data

The paper fraction of the OMSW has been shown to be the most difficult organic fraction in anaerobic degradation. Newsprint contains 80% machine produced pulp and paper and therefore has the highest lignin content of all cardboard and papers. Lignin is thought to be insoluble and non-biodegradable under anaerobic conditions. It has negative effects on degradation when combined with cellulose (Graindorge, 1989). Ligneous structure within an organic complex tends to shield the cellulose materials from enzymatic hydrolysis (Hills, 1980b).

As already mentioned earlier, the seeding with sewage sludge has been shown to enhance the performance of a high solids process. DeBoosere et al. (1986) speculated that the digestion of paper and paper sludges could benefit from supplementation of animal manures before digestion in view of the low nitrogen and phosphorous levels.

The quality of OMSW has been shown to affect digester performance, operating at 6% TS. Improvements in microbial activity were observed when separate collection was performed, instead of source separation of the organic fraction (Cecchi et al. 1988).

Six and Debaere (1988) studied the digestion of several different wastes. Their results shown in Table 3 indicate that decomposition of incoming waste was affected by the waste composition as well as by the method of collection. The collection method may introduce greater inerts but may also add

| | Initial TS (%) | Loading (kg COD/m$^3$r*d) | COD reduction (%) |
|---|---|---|---|
| Mixed MSW | 56 | 17.3 | 55 |
| Separately collected | | | |
| MSW - Duobak | 43 | 20 | 55 |
| - fruit, veg.+ garden waste | 35 | 10 | 50 |
| Restaurant waste | 19 | 11 | 95 |
| Paper Sludge | 5 | 11 | 55 |
| MSW:WSS 2:1 | 39 | 19 | 56 |

(Six and DeBaere, 1988)

Table 3: Anaerobic Digestion of Various Organic Wastes

needed nutrients. In Table 3, the mixed MSW at 56% TS achieved the same COD (chemical oxygen demand) reduction as the source separated waste at 43% TS at similar loading rates. This seems to conflict with the findings of Cecchi et al. (1988) reported earlier.

As seen from the other organic wastes listed, COD reduction varies. The separately collected vegetable waste has the lowest COD reduction. This low removal was reported to exist due to the rapid acidification in the reactor (Six and DeBaere, 1988).

Composition of the digestate as reported by various researchers affect digester performance. Rheology of mixing may be a problem when using high paper and cardboard contents (Graindorge et al., 1989). Acidification may exist with pure vegetable wastes (Six and DeBaere, 1988) or there may lack of essential compounds necessary for microbial maintenance and growth.

## 2.6 End-Product Use

The use of the digested blend of OMSW and sewage sludge has found several applications as a soil conditioner. For use as a soil conditioning agent, the C/N (carbon/nitrogen) ratio has been recommended to be between 10 and 20 (Price and Cheremisinoff, 1981). At this ratio the compost is considered stabilized. At higher C/N ratios carbon and ammonia nitrogen exert a high oxygen demand, causing septic conditions, which often lead to high acidity levels.

DeBaere et al. (1987) found the anaerobically digested OMSW to have a C/N of 12 to 15 after three weeks of digestion. The cumulative oxygen consumption equalled that of aerobic compost of 4 to 6 months, indicating a high degree of stability. Fecal bacteria were almost completely absent (Debaere et al., 1987). It was the opinion of these researchers that the anaerobically digested OMSW was more hygienic and displayed greater stability than OMSW aerobically composted for 4 months. The net effect was a more desirable soil conditioning agent.

Digested piggery and dairy wastes have been tested successfully as livestock fodder, a component in particle board, and as an agricultural fertilizer (Marchaim and Creden, 1981 in Kimchie et al., 1988).

Sources of heavy metals have been a concern in compost. Heavy metals in the compost have been reduced by 45 to 55% by pre-sorting MSW, thereby avoiding partial solubilization during digestion (Cayrol et al., 1988). If sludge has been added, the quantity of metals and pollutants determines the use of the digestate. Lower quality compost has been used in land reclamation projects.

In addition to compost, biogas results from the fermentation process. One cubic meter of methane at standard temperature and pressure has a net heating value of 35,800 kJ/m$^3$ (Metcalf and Eddy, 1979). Biogas has a 50 to 65% methane content (DeBaere et al. 1987). With a 55% $CH_4$ content, digester gas has a heating value of approximately 19,690 kJ/m$^3$.

## 2.7 Concluding Remarks

The literature survey above, presents the findings of research in dry anaerobic digestion in municipal solid waste to date. Some results are conclusive such as the importance of mass retention time. The reported effects of temperature are conflicting. Researchers indicate optimum TS, for OMSW anaerobic digestion, may be between 30 and 35%. Digestion of high newspaper-content OMSW has not been adequately addressed to date.

This study attempts to determine the optimum conditions for high solids "dry" anaerobic digestion of typical high cellulosic North American waste.

Operational variables considered in the study were: temperature, solids concentration, MSW:WSS ratio and mass retention time. Performance was evaluated using: biogas productivity, biogas composition, removal efficiency, VFA concentration, pH and alkalinity.

# 3.0 EXPERIMENTAL METHODS

## 3.1 Experimental Design

A conservative and economic fractional factorial experimental design (DEXP) was conceived to screen the main variables that could affect the digestion at high TS contents (Montgomery, 1984). The DEXP was made up of four levels of TS (25%, 30%, 35%, and 40%), two levels of temperature (mesophilic at 39 °C and thermophilic at 53 °C), mass retention time (MRT) at two levels (15 and 21 days) and ratio at two levels as well. The ratio is the proportion of total weight of MSW to total weight of WSS in the feed. The responses measured were biogas productivity, percent methane, TS and VS, alkalinity, pH, and VFA concentration.

Table 4 shows the particular set of factors for the 16 reactors used in the DEXP. Several other reactors were operated simultaneously alongside the 16 of the DEXP. Data from these 4, 2 at each temperature, are used where appropriate. These reactors are not incorporated into the analysis of variance (ANOVA) because they were not part of the DEXP set-up. Table 5 lists the additional reactors with their operational factors.

| Reactor | Temperature °C | Nominal TS % | Ratio MSW/WSS | Retention Time days |
|---|---|---|---|---|
| Mesophilic | | | | |
| M1 | 39 | 25 | 1 | 21 |
| M2 | 39 | 25 | 2 | 15 |
| M3 | 39 | 40 | 1 | 21 |
| M4 | 39 | 40 | 2 | 15 |
| M5 | 39 | 30 | 1 | 15 |
| M6 | 39 | 35 | 1 | 15 |
| M7 | 39 | 35 | 2 | 21 |
| M8 | 39 | 30 | 2 | 21 |
| Thermophilic | | | | |
| T1 | 53 | 30 | 1 | 21 |
| T2 | 53 | 40 | 1 | 15 |
| T3 | 53 | 40 | 2 | 21 |
| T4 | 53 | 30 | 2 | 15 |
| T5 | 53 | 35 | 1 | 21 |
| T6 | 53 | 35 | 2 | 15 |
| T7 | 53 | 25 | 1 | 15 |
| T8 | 53 | 25 | 2 | 21 |

Table 4: Experimental Design Set-up

| Reactor | Temperature °C | Nominal TS % | Ratio MSW/WSS | Retention Time days |
|---|---|---|---|---|
| M0 | 39 | 30 | 2 | 15 |
| M9 | 39 | 20 | 2 | 15 |
| T0 | 53 | 30 | 2 | 21 |
| T9 | 53 | 20 | 2 | 15 |

Table 5: Additional Experimental Reactors

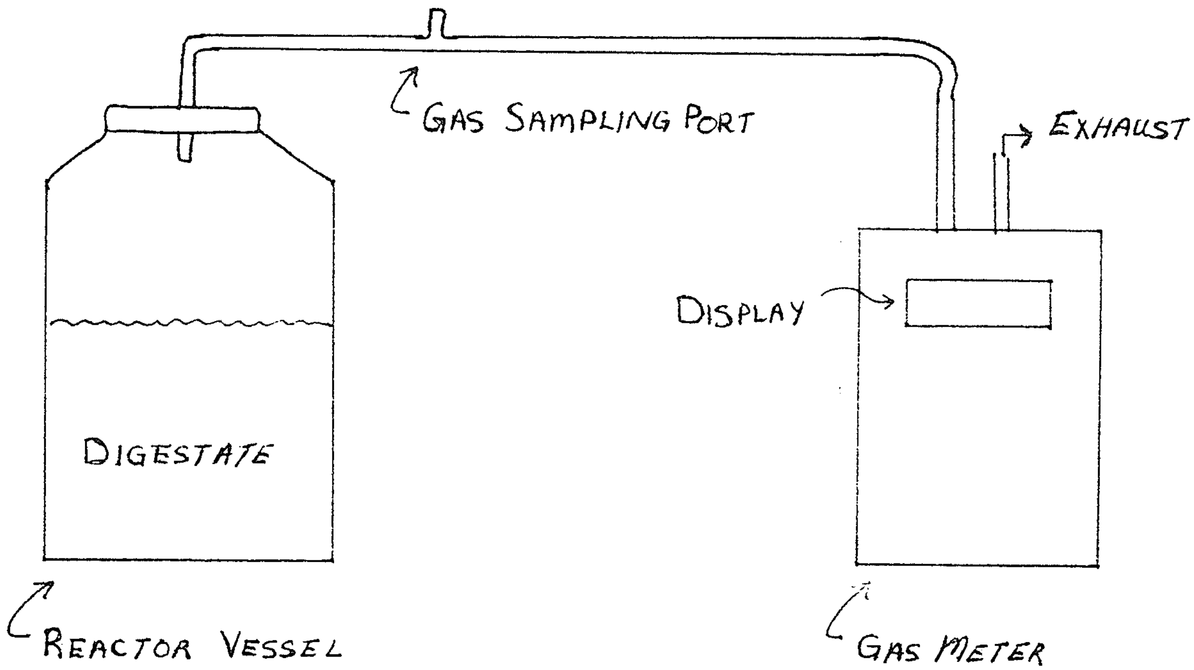


Figure 1: Schematic of Reactor with Gas Meter

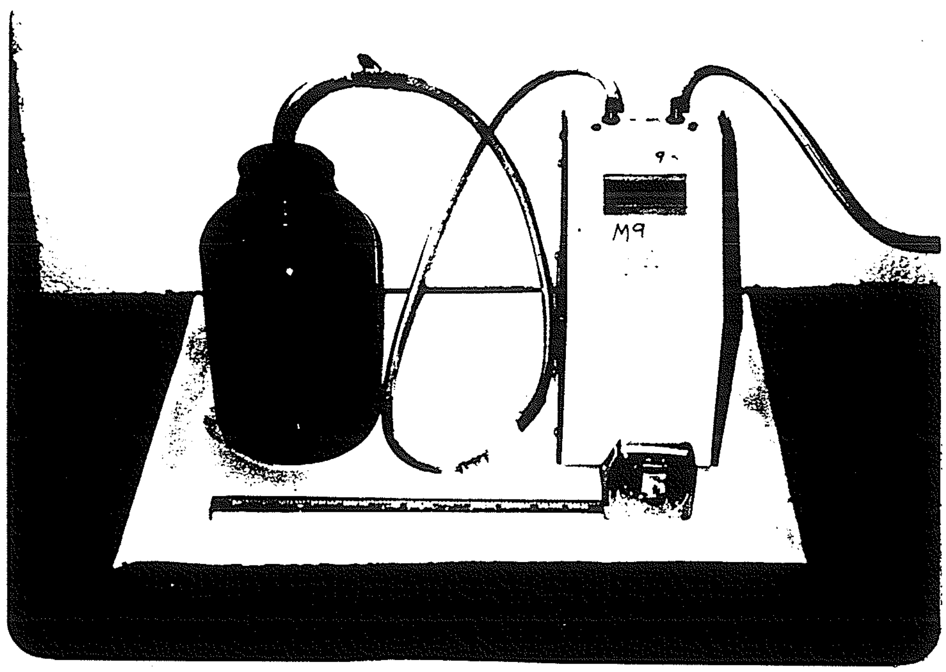

Figure 2: Typical Reactor Set-up

## 3.2 Reactor Set-up

Each reactor consisted of a glass jar approximately 3 litres in volume. Figure 1 schematically illustrates a reactor with attached gas recording apparatus. Figure 2 is a photograph of a typical reactor set-up. Two separate water baths were maintained at 39 °C +/- 1 °C, mesophilic, and 53 °C +/- 1 °C , thermophilic, using Hach Models E100 and D800 temperature controllers.

## 3.3 Feed Preparation

A large quantity of semi-synthetic feed was prepared and frozen for use on as-needed basis. The feed consisted of newsprint, food waste, and WSS. Newsprint was shredded to short strips approximately 10 mm by 50 mm in size. Only non-coloured newsprint was used. Food waste was obtained from the campus cafeteria and consisted mainly of discarded prepared breakfast and lunch foods. The blended food waste had a 42% total solids content. The WSS was obtained from the Town of Selkirk storage pond, with a total solids content of 11%. Ratio R1 was defined as a 1:1 MSW:WSS ratio based on total weight. Ratio 1 contained 9.8 parts shredded newsprint to 1.2 parts food waste to 1 part WSS on a total solids basis. Ratio R2 is 2:1 MSW:WSS. Ratio 2 contained 19.7 parts newsprint, 2.3 parts food waste and 1 part WSS on a total solids basis. Newspaper accounted for 89% of the synthetic

OMSW on a TS basis. The food waste accounted for the remaining 11%.

Feed stocks were prepared monthly. Exact feed solids for each reactor were prepared for several feedings, at one time. All feeds were stored in a deep freeze at -20 °C and allowed to thaw overnight at 4 °C, before feeding. Sodium bicarbonate was added proportionally to the mass loading rate and solids content of the reactor on an as-needed spot basis. Appendix A provides a listing of all $NaHCO_3$ additions.

### 3.4 Digester Start-Up

Initial start-up of the digesters was in slurry form. Each digester was seeded with 1 litre anaerobic sludge, obtained from the City of Winnipeg North-End Water Pollution Control Centre digesters. To this, 0.3 litres fresh cow manure, from the University Dairy Sciences and 0.45 litres of prepared OMSW was added. This slurry was flushed with nitrogen gas for 10 minutes before sealing reactor. The weights of each reactor were recorded before and after addition of the start-up mixture.

Each reactor was brought to the specified solids concentration gradually. Prepared substrate was fed twice a week to each reactor. The desired TS content and reactor mass was reached in two retention times, approximately 6 weeks. To ensure stable conditions, an additional six weeks of continuous operation were allowed to pass before the data used for comparative analysis was gathered.

## 3.5 Feeding

The draw and feed operation was performed on an intermittent basis twice weekly. Later during the study, the draw and feed schedule was reduced to 3 times every two weeks. Oxygen contamination in the reactor was minimized during solids transfer by nitrogen flushing. Reactors were mixed manually by shaking for one minute each day.

## 3.6 Analysis

A monitoring schedule was developed to determine effectively the status of the anaerobic digesters. The schedule is shown in Table 6.

Biogas production was recorded each morning. Biogas production was measured using a Low Flow Rate Gas Volume Meter Model 181, Triton Electronics Limited, as shown in Figure 2. This meter measured cumulative biogas production by repeated cell volume displacement, with +/- 50 mL accuracy.

In other reactors biogas production was measured by liquid displacement using a saturated NaCl with 5% $H_2SO_4$ solution.

Preparation of samples for pH, alkalinity, and VFA was based on procedures developed by Kasali et al., 1989. and modified by Poggi et al. 1989. Fifty millilitres of 4 $^{o}$C deionized water was added to a 10 g sample of solid waste effluent. This slurry was stirred vigorously with glass rod for 15 seconds and allowed to stand 10 minutes in the refrigerator. This sample was stirred once more before pH was

| Parameter | Frequency |
|---|---|
| Biogas Production | daily |
| Biogas Composition | 2/week |
| pH | 2/week |
| Reactor Mass | 2/week |
| Solids | 2/week |
| Alkalinity | weekly |
| VFA | weekly |
| Sodium | biweekly |
| Ammonia | monthly |

Table 6: Analysis Schedule

taken. The pH was measured using a Fisher Accumet Model 230 pH/Ion Meter with a Baxter slimline probe.

Following pH determination the slurry was filtered using a coarse 1.8 mm mesh filter funnel. This filtrate was centrifuged for 15 minutes at 3000 r.p.m. using a Damon/IEC HN-S Centrifuge operating in a 4 °C environmental chamber.

A 20 or 25 ml centrate sample was then taken for alkalinity determination using 0.2 N $H_2SO_4$ following Standard Methods (A.P.H.A., 1985). Potentiometric points used for phenolphthalein, intermediate and total alkalinity were pH 8.3, 5.75 and 4.2 respectively.

Total solids were determined by drying a 10 g sample 12 hours at 103 °C. Dry samples were ashed at 550 °C for 6 hours to determine volatile solids.

Biogas composition was determined using a Gow Mac 550 gas chromatograph thermal conductivity detector. Helium carrier gas was used at a flowrate of 10 ml/min. Stainless steel 1.8 m by 6 mm columns were packed with Poropak Q, 80/100 mesh to determine methane and carbon dioxide concentrations and Molecular Sieve 5A 60/80 packing, to confirm absence of oxygen. Column temperature was 55 °C, detector temperature 110 °C, injection port temperature 95 °C, and the bridge current 150 mA for both columns.

For volatile fatty acid determination, 1.5 ml of centrate sample was further centrifuged using a high speed IEC Centri-M Centrifuge for 10 minutes. VFA was determined using a Hewlett Packard 5890 Gas Chromatograph thermal conductivity detector. Column used was a HP-FFAP 10 m x 5.3E-4 m x 1.0E-

6 m capillary column. Compressed air was the carrier gas at 13-14 ml/min; nitrogen make-up gas at 7-8 ml/min; $H_2$ to flame ionization detector (F.I.D) at 30-31 ml/min; air to F.I.D at 450 ml/min. The HP-GC 5890 was programmed to allow VFA to elute in less than 4 minutes with the following temperature program: initial oven temperature 85 $^{o}C$; initial oven time 1.5 min; initial oven rate 20 deg/min; final temperature 123 $^{o}C$; final time 1.0 min; rate A 30 deg/min; final temperature A 153 $^{o}C$; final time A 1.0 minutes. Output was integrated and recorded using a Waters 740 integrator.

## 4.0 RESULTS AND DISCUSSION

Results of the 10 weeks of steady-state operation have been compiled in Appendix B. Both averages and standard deviations are presented where appropriate. The last 4 weeks of data have been combined where averages are presented. In this period reactors were buffered with sodium bicarbonate on an as-needed basis and reseeding of upset digesters was kept to a minimum. A listing of additions other than regular feed is found in Appendix A. The following discussion will focus mainly on digester averages.

Conventionally, with factorial design experiments (DEXP), design parameters are pooled except the one to be examined. An analysis of variance (ANOVA) table was created to define significance of effects. Table 7 shows the significance of the factor under examination (Hicks, 1982).

Figures 3 through 6 are bar graphs displaying the effects of total solids, temperature, ratio, and retention time respectively. In Figure 3, ratio, retention time and operating temperature are pooled and feed total solids remains as a variable. The same procedure is carried throughout. In Figure 6, the 21 day VFA bar represents an average VFA concentration of all digesters with a 21 day retention time, both mesophilic and thermophilic.

| SOURCE | Removal Efficiency | Biogas Production | Volatile Fatty Acids | Volumetric Removal Rate | Removal Rate | Methane |
|---|---|---|---|---|---|---|
| Main Factors: | | | | | | |
| Total Solids | v.s. | v.s. | s. | v.s. | v.s. | n.s. |
| Temperature | m.s. | v.s. | m.s. | v.s. | s. | n.s. |
| Mass Retention Time | h.s. | s. | h.s. | s. | m.s. | s. |
| Ratio | s. | v.s. | n.s. | v.s. | s. | w.s. |
| Interactions: | | | | | | |
| TS*T | n.s. | w.s. | n.s. | w.s. | n.s. | n.s. |
| TS*MRT | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| TS*MRT*T | n.s. | m.s. | n.s. | m.s. | w.s. | n.s. |

note: TS*T*MRT = TS*R

```
h.s.    v.s.    s.      m.s     w.s     n.s
<-----* <-----* <-----* <-----* <-----* <-----
 0.01    0.05    0.10    0.15    0.20
```

h.s - highly significant
v.s - very significant
s - significant
m.s - moderately significant
w.s - weakly significant
n.s - not significant

Table 7: Analysis of Variance

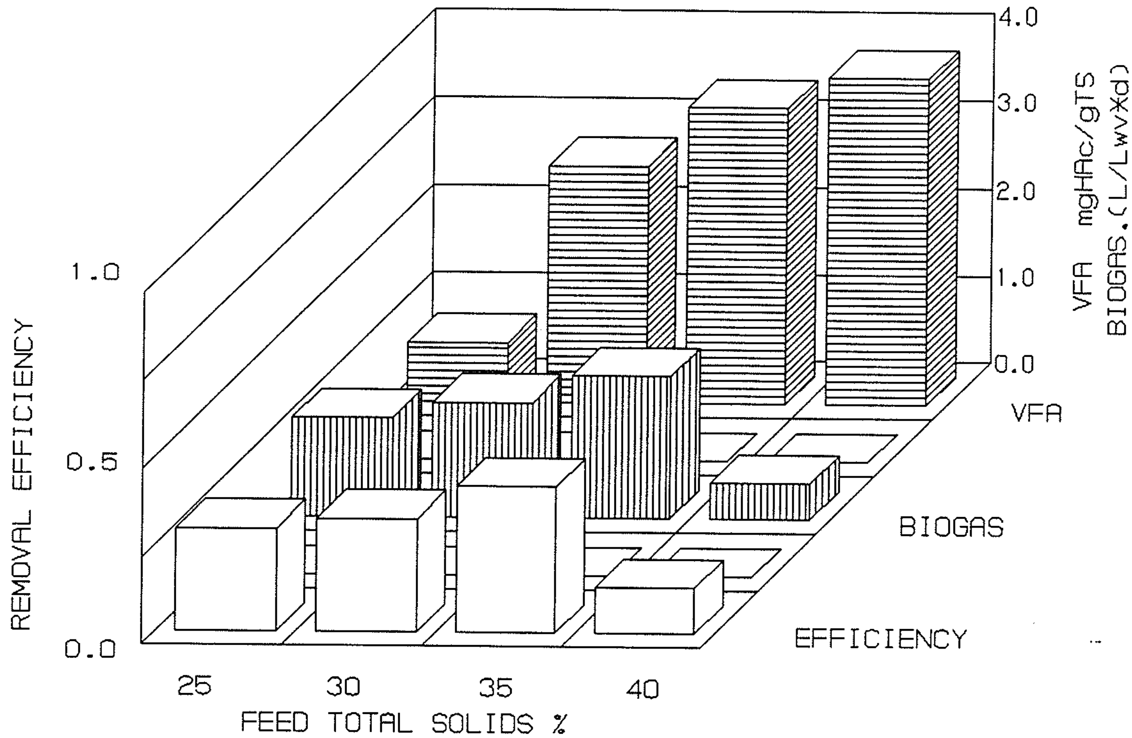


**Figure 3: Effect of Total Solids on Responses**

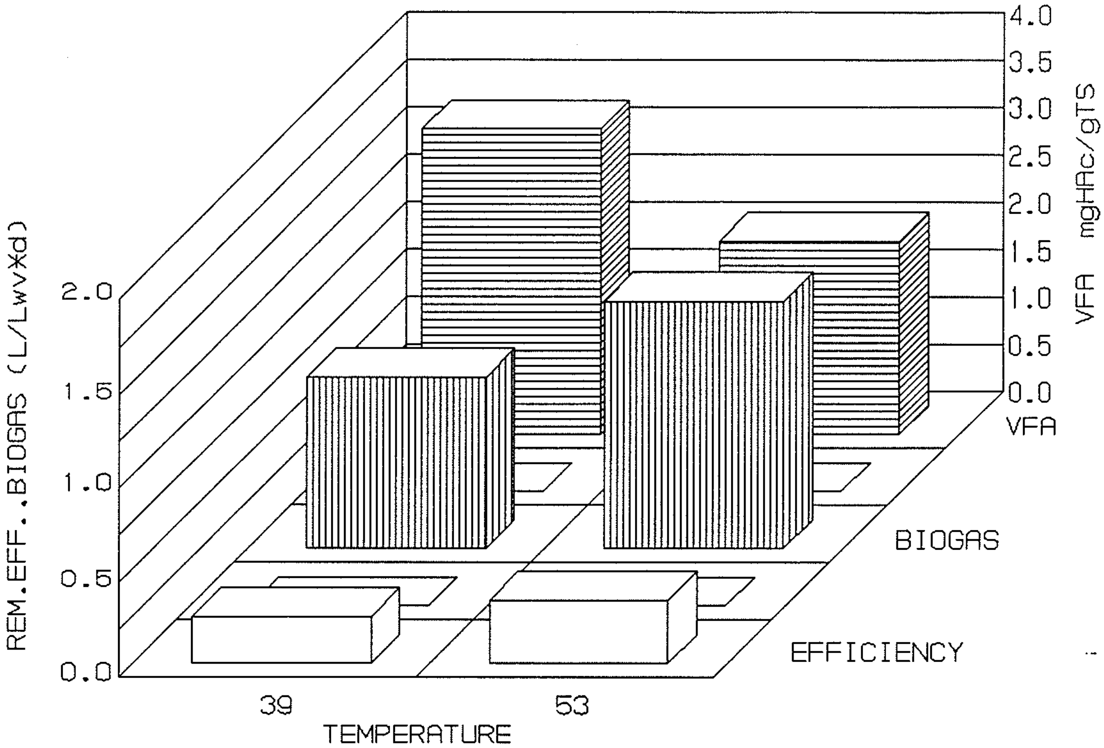


Figure 4: Effect of Temperature on Responses

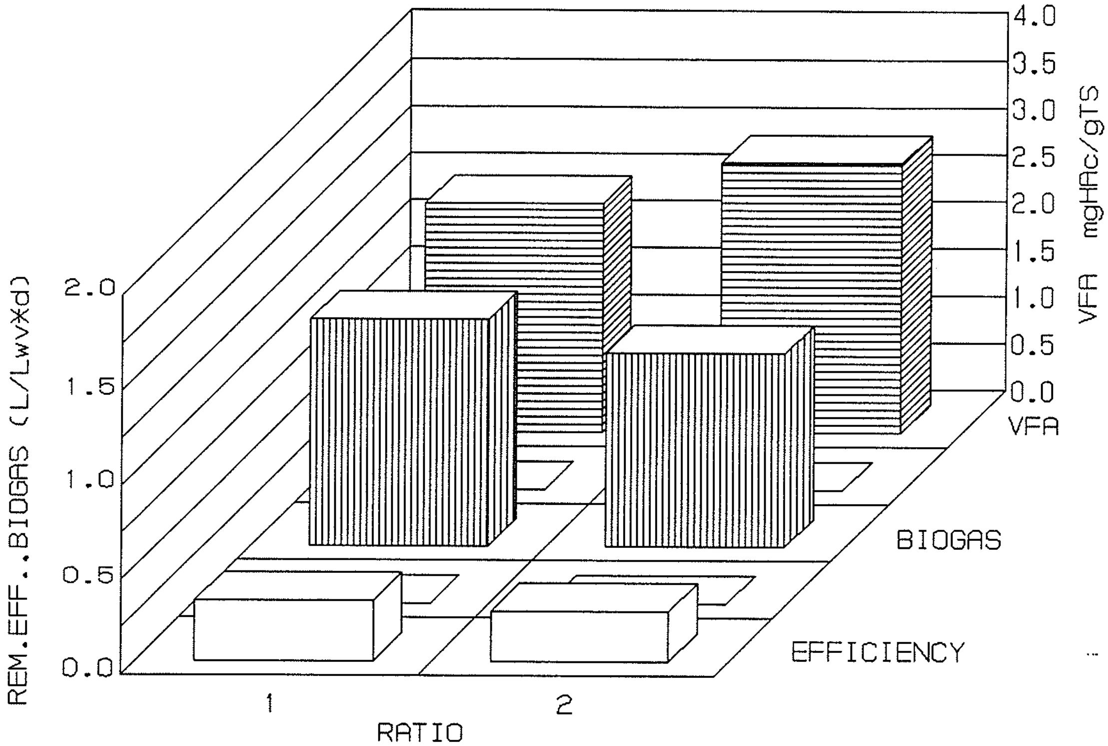


Figure 5: Effect of Ratio on Responses

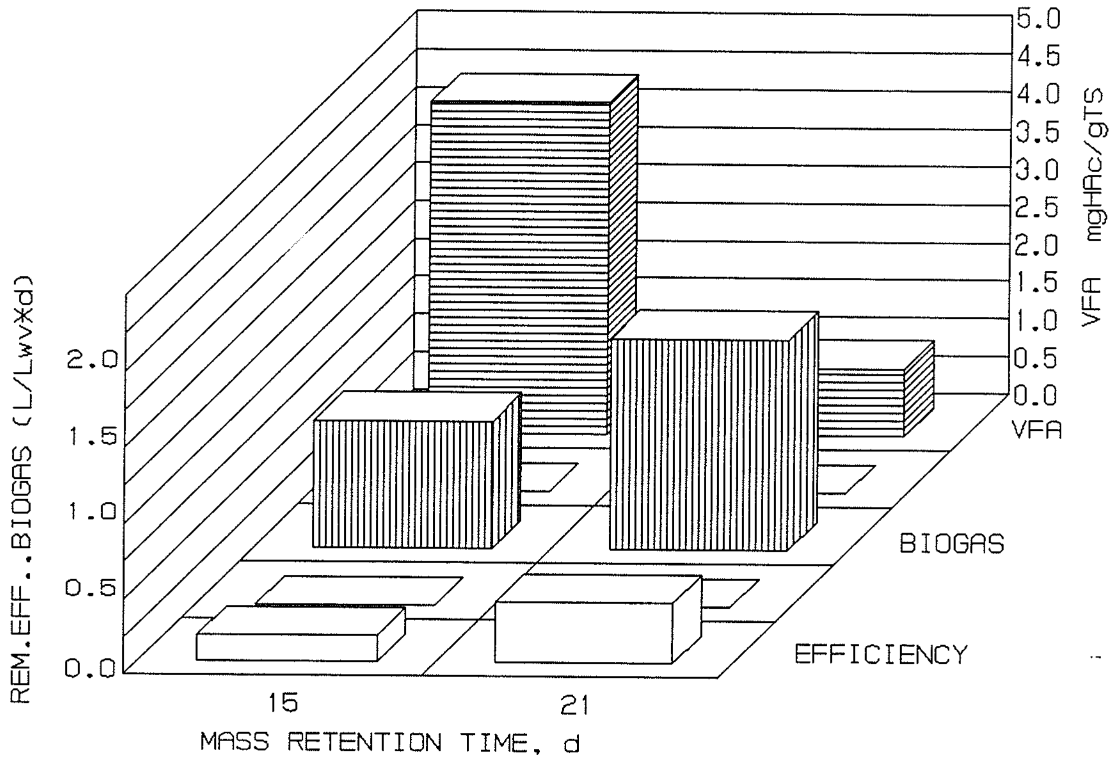


Figure 6: Effect of Retention Time on Responses

4.1 Total Solids

An overview of the solids effect can be seen from the line bars of Figure 3. There did not appear to be a linear effect as might be expected. Efficiency did not decrease linearly with an increase in solids as in sewage sludge. By plotting removal efficiency against feed total solids, there appeared to be a quadratic effect, as shown in Figure 7. There was an optimum experienced somewhere between 30 to 35% TS especially in the 21 day retention time (RT). The 15 day RT did not highlight the solids effect except near 40% where there was a sharp decrease in efficiency.

The effect of total solids on biogas productivity was similar to removal efficiency. Examining Figure 8, a similar optimum was realized between 30 to 35% TS at 21 day RT in both thermophilic and mesophilic. With the shorter retention time of 15 days, there seemed to be a linear effect in productivity followed by a sharp decline in biogas beyond 35% TS. The 25% TS 15 day RT was unexplainably low. This digester experienced several failures and would not operate in a healthy state for extended periods of time. Total solids appeared to have a less significant effect on biogas productivity when accompanied by a shorter retention time.

When ratio of OMSW:WSS was considered as the variable against total solids, as in Figure 9, the results were less clear. The thermophilic ratio 1 (R1) has the greatest biogas productivity. The greater percentage of sludge present aided in higher gas volumes; i.e. greater nutrient supply was

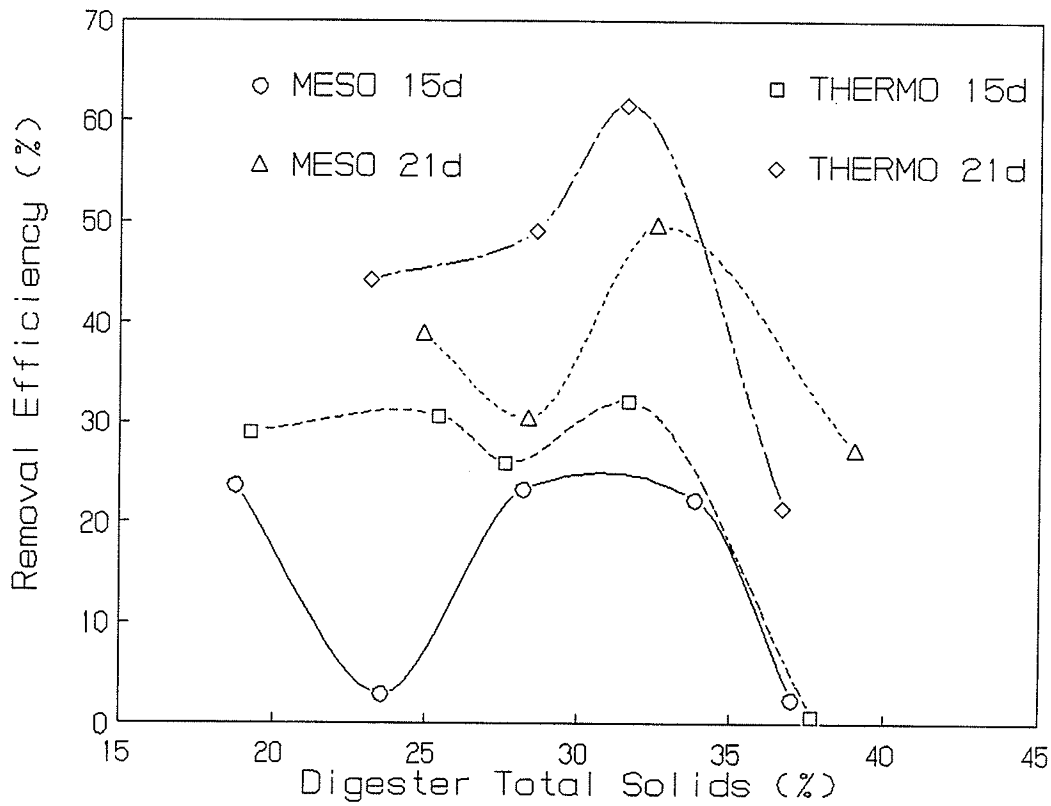


Figure 7: Retention Time, Removal Efficiencies vs Total Solids

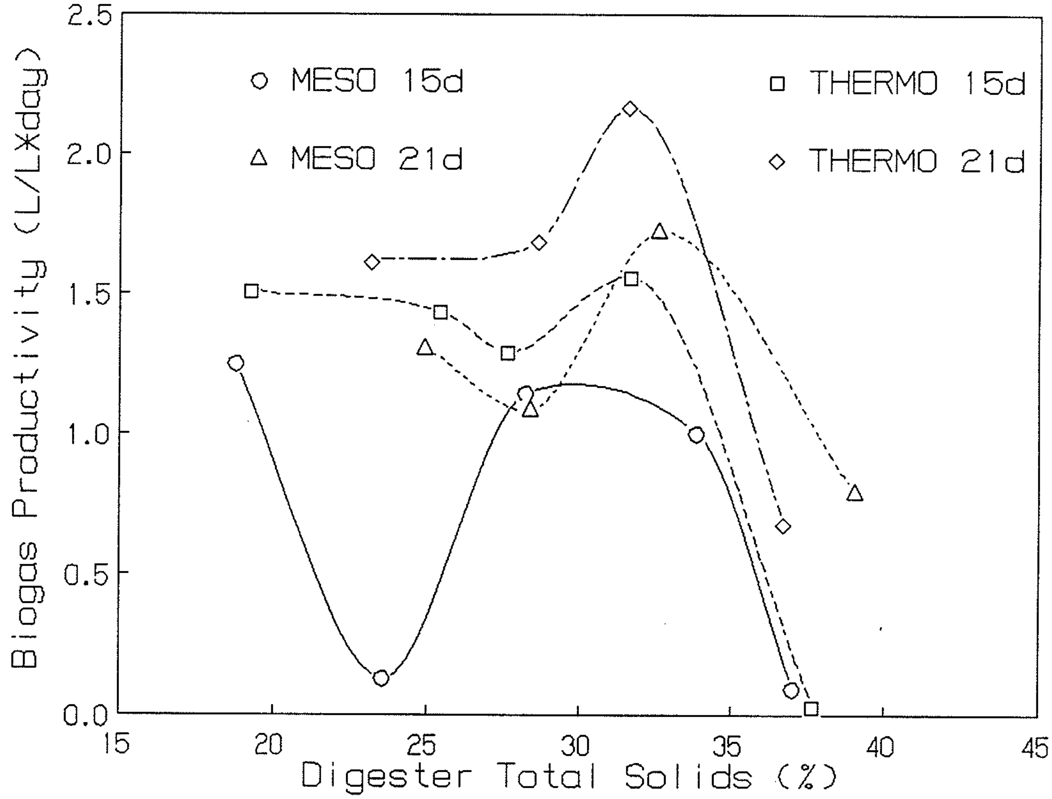


Figure 8: Retention Time, Biogas Productivity vs Total Solids

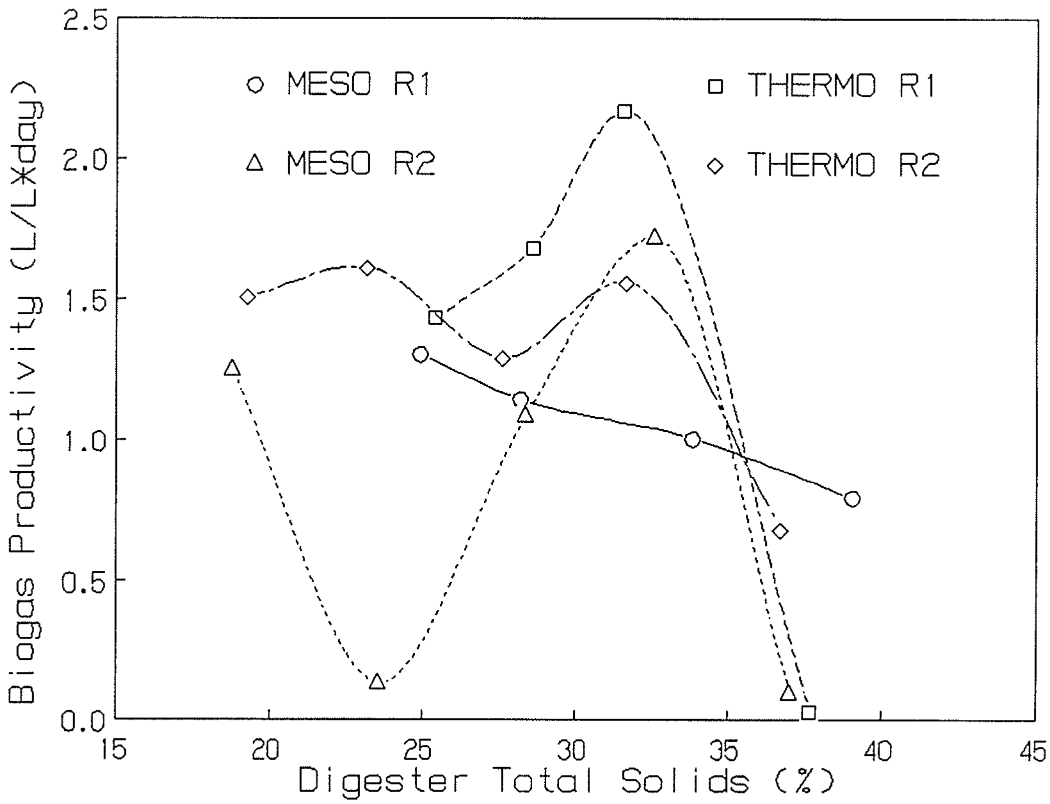


Figure 9: Ratio, Biogas Productivity vs Total Solids

available for microbial maintenance and growth. Thermophilic R2 gave a similar but less significant quadratic effect, with a possible optimum near 25% TS. Peak biogas productivity was 30% less with ratio 2 than with ratio 1.

Figure 3 displays a stepwise increase in VFA concentration with an increase in TS up to 35%. There was less than a 10% increase in VFA from 35 to 40% TS, possibly indicating inhibition to the hydrolysis and acidogenic processes at 40% TS. When this VFA data is examined in greater detail in Figures 10 and 11, it can be seen that the shorter RT contributed most greatly alongside TS to create this build-up in acids. Mesophilic and thermophilic reactors gave similar results at 21 day RT. A low or intermediate level of fatty acids was necessary as a precursor to biogas production. However, a high level of VFA, greater than 4 mg HAc/gTS, inhibited methanogenesis resulting in further acid build-up and eventual failure of the digester.

The 30 to 35% TS range was higher than the optimum experienced for manure substrates, where methane production decreased considerably at 30 to 35 % TS (Wujcik and Jewell, 1980). This optimum was similar to the TS ranges expressed by operators of the Valorga and Dranco processes where a highly fermentable waste was digested (Cayrol et al., 1988; DeBaere, 1985). However, when a high paper and cardboard content OMSW was used (Graindorge et al., 1989), 25% TS was recommended. The addition of WSS, in the present study, may have aided in allowing higher operating solids concentrations.

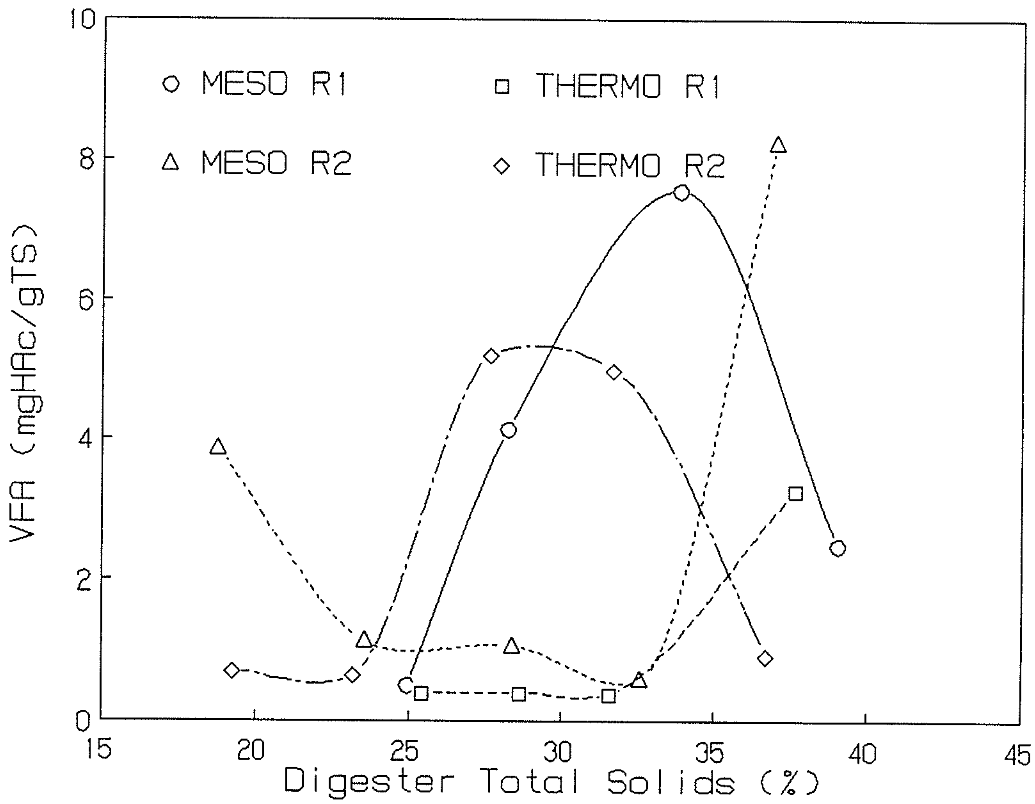


Figure 10: Ratio, Volatile Fatty Acids vs Total Solids

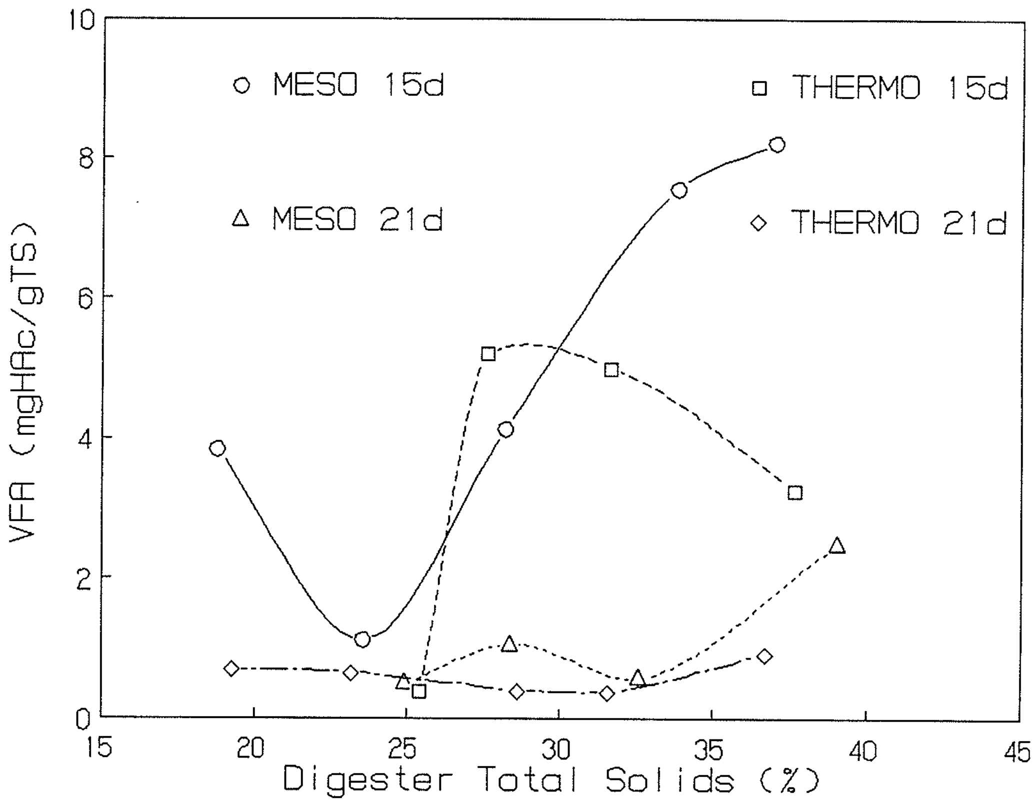


Figure 11: Retention Time, Volatile Fatty Acids vs Total Solids

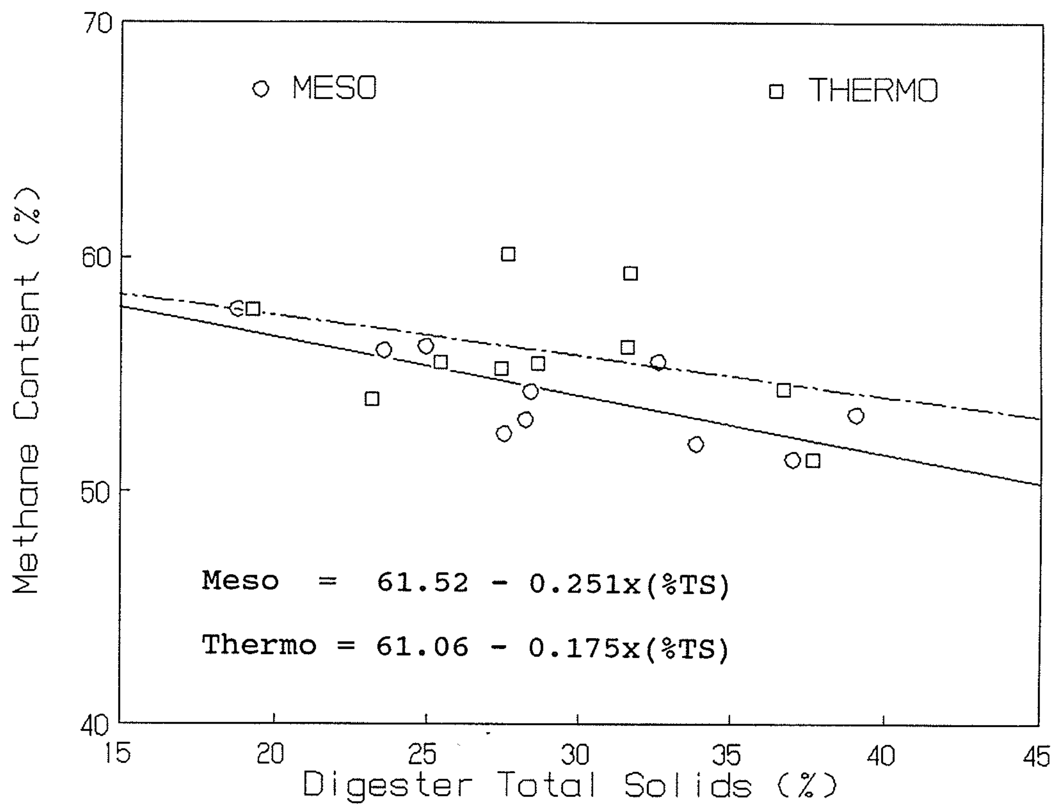


Figure 12: Temperature, Methane Content vs Total Solids

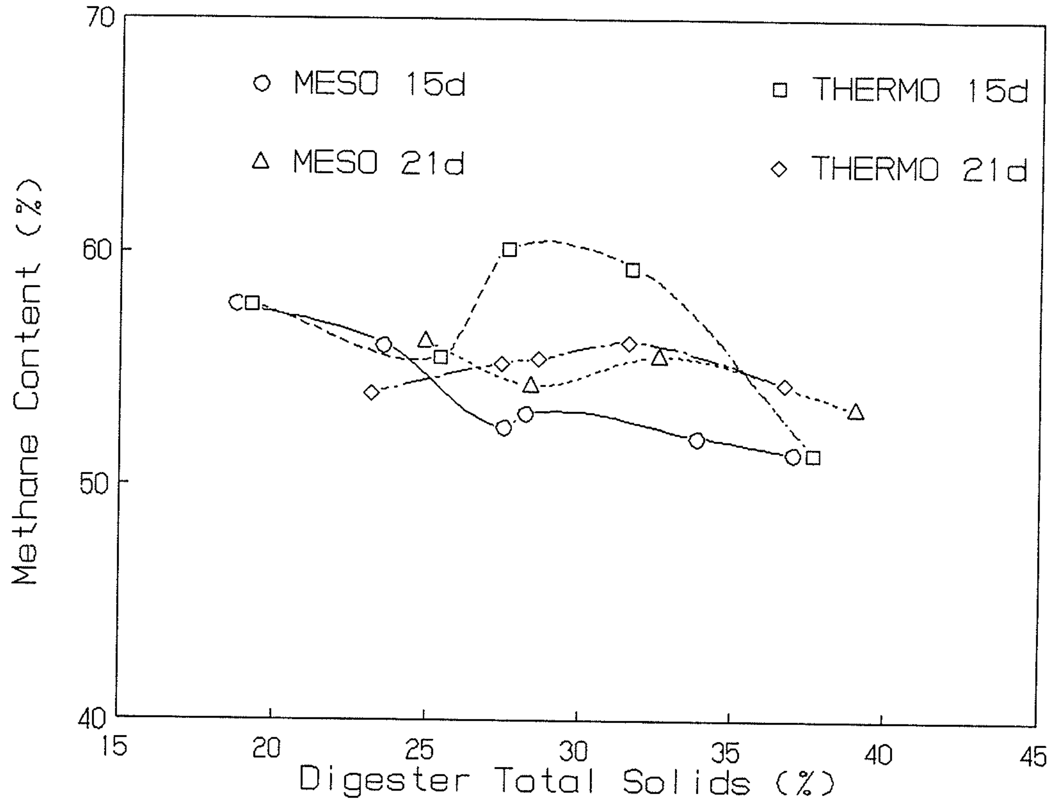


Figure 13: Retention Time, Methane Content vs Total Solids

The effect of TS on methane content was minimal. The average methane concentration ranged from a low of 51.4% to a high of 60.2% $CH_4$. Some digesters which failed still exhibited high methane values. Graindorge et al. (1989) noted that methane content did not fall in failing digesters. There was a slight decline in methane content with increasing TS. The observed decline was near 5% with a 25% increase in TS. A linear regression performed on the methane contents of all reactors illustrates the low rate of decline with TS increase, Figure 12. There was a slightly higher methane content in both mesophilic and thermophilic 21 day RT digesters (Figure 13), indicating that healthier reactors may have higher methane contents, as one might expect. The slight difference in methane contents indicated however that methane would not be useful in day-to-day monitoring of digester health.

## 4.2 Temperature

The effects of operating temperature are twofold. An increase in operating temperature, from 39 °C to 53 °C, improved removal efficiency 25%, and biogas production 30%, on average. Average VFA concentration was also reduced (Figure 4). However, process stability was reduced. Several of the thermophilic reactors experienced upsets resulting in low pH, and low biogas production and/or high VFA concentration.

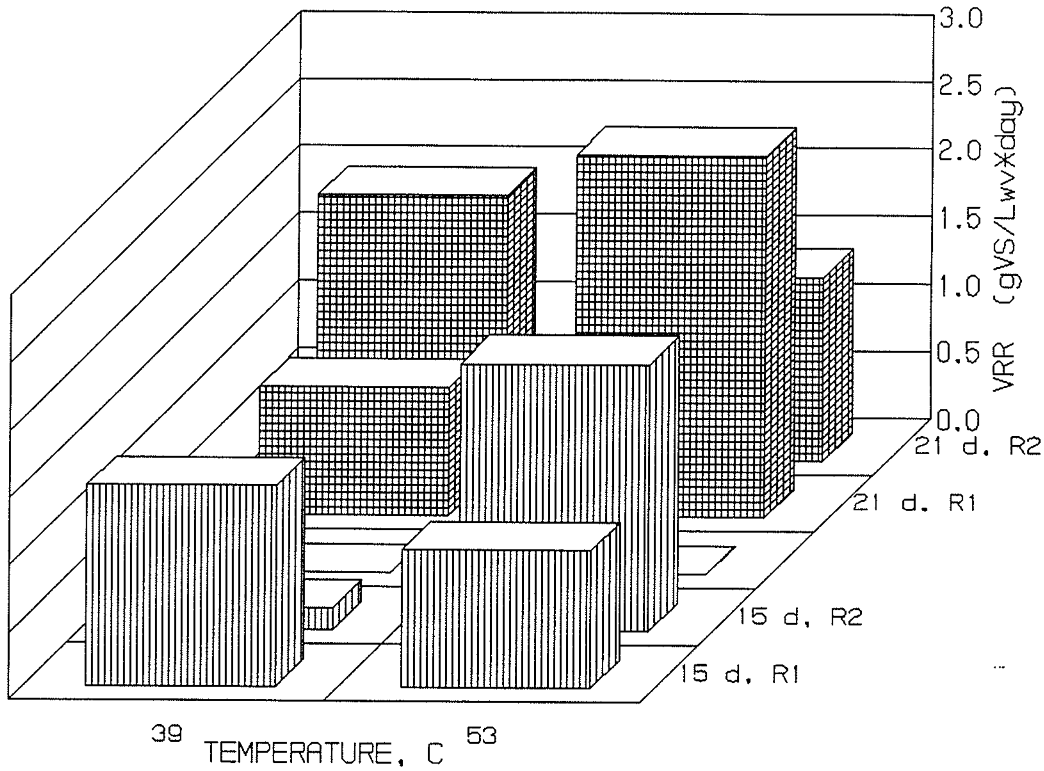


Figure 14: Temperature vs Volumetric Removal Rate

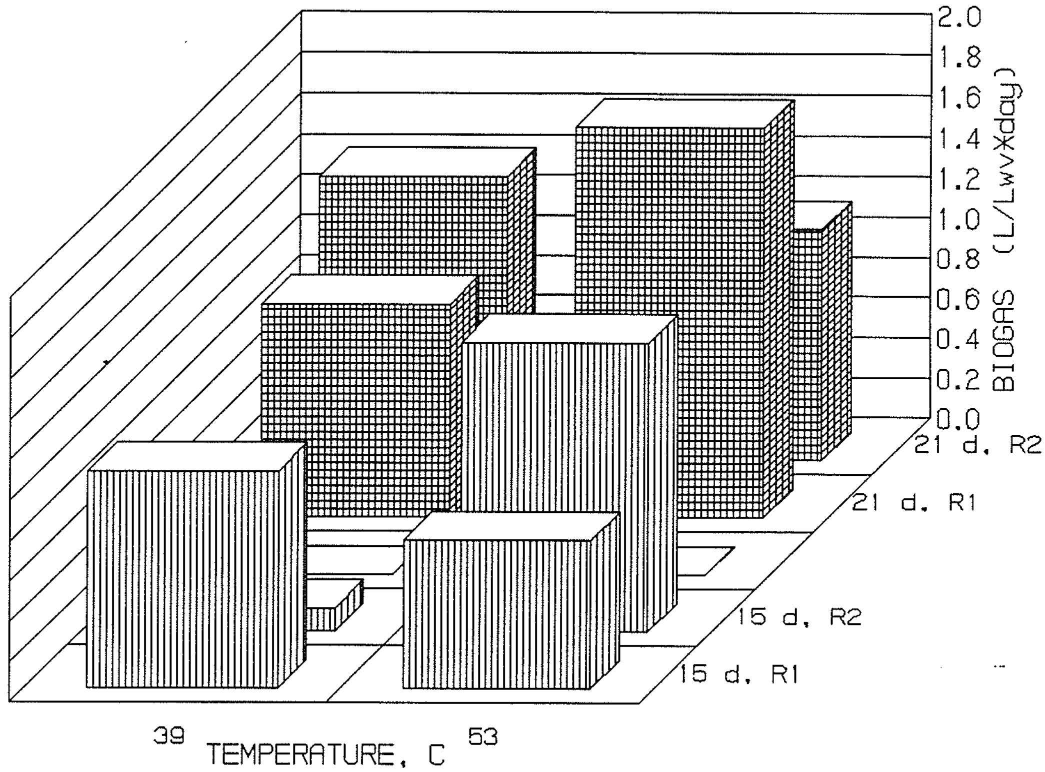


Figure 15: Temperature vs Biogas Productivity

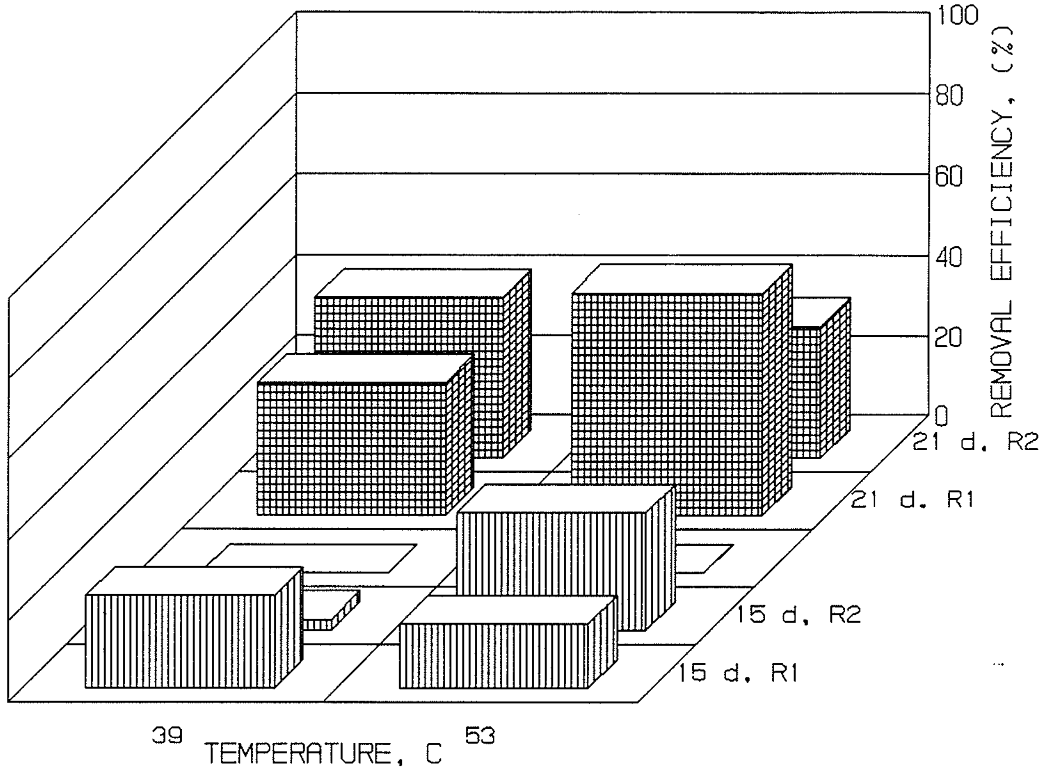


Figure 16: Temperature vs Removal Efficiency

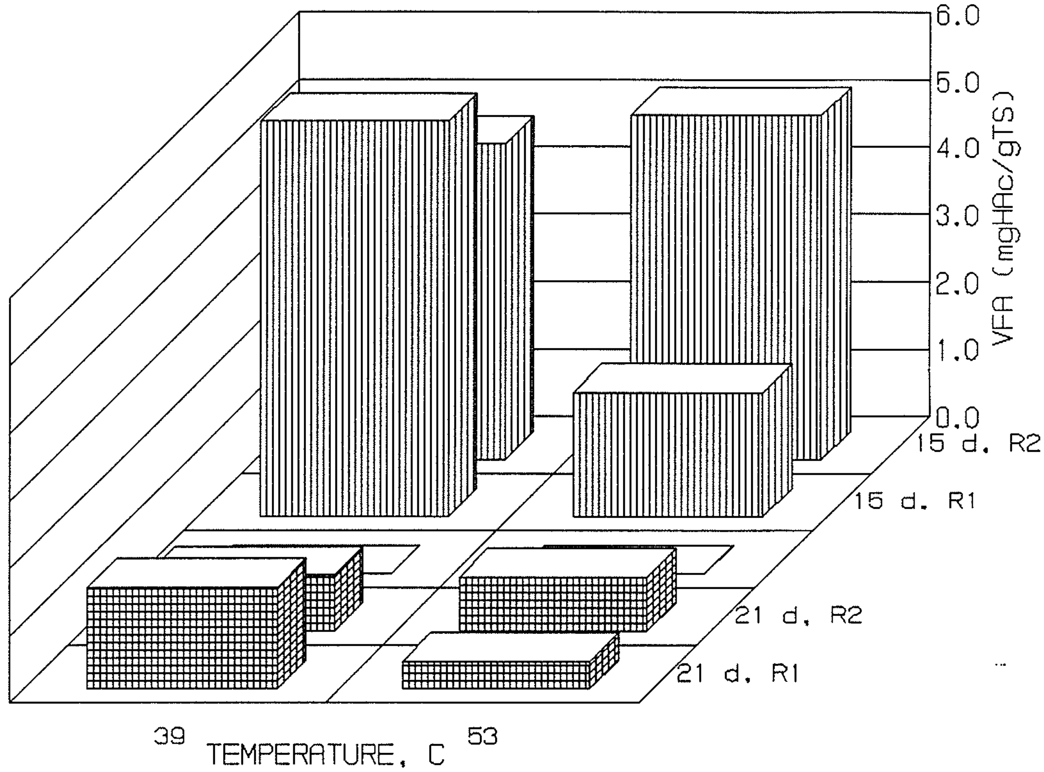


Figure 17: Temperature vs Volatile Fatty Acids

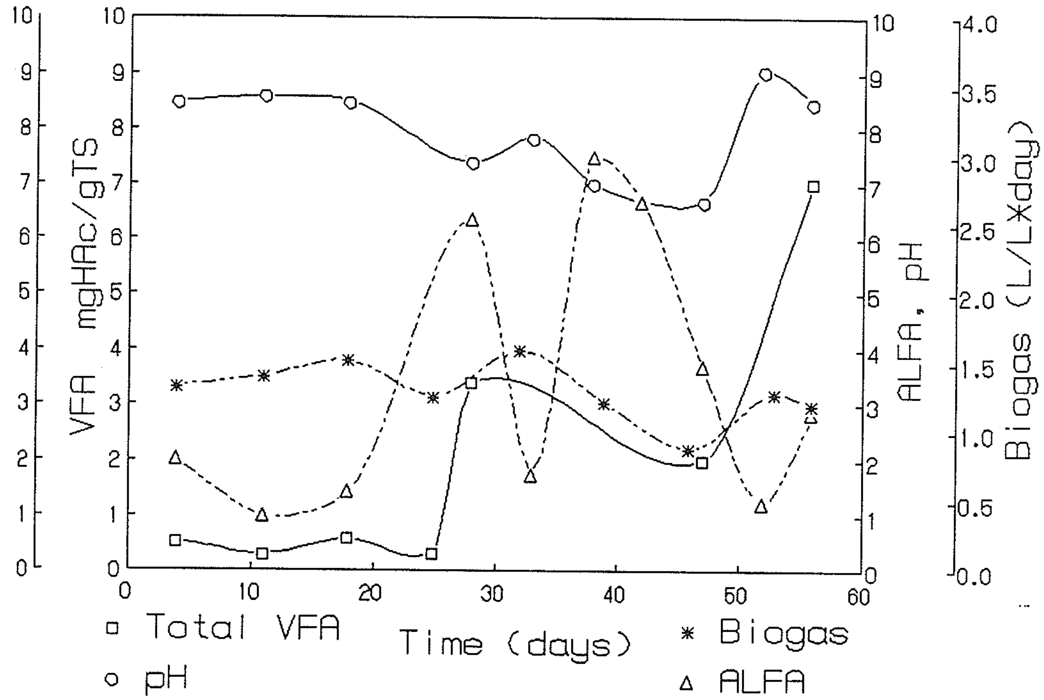


**Figure 18: Mesophilic: 30% TS, 15 day RT, R1**

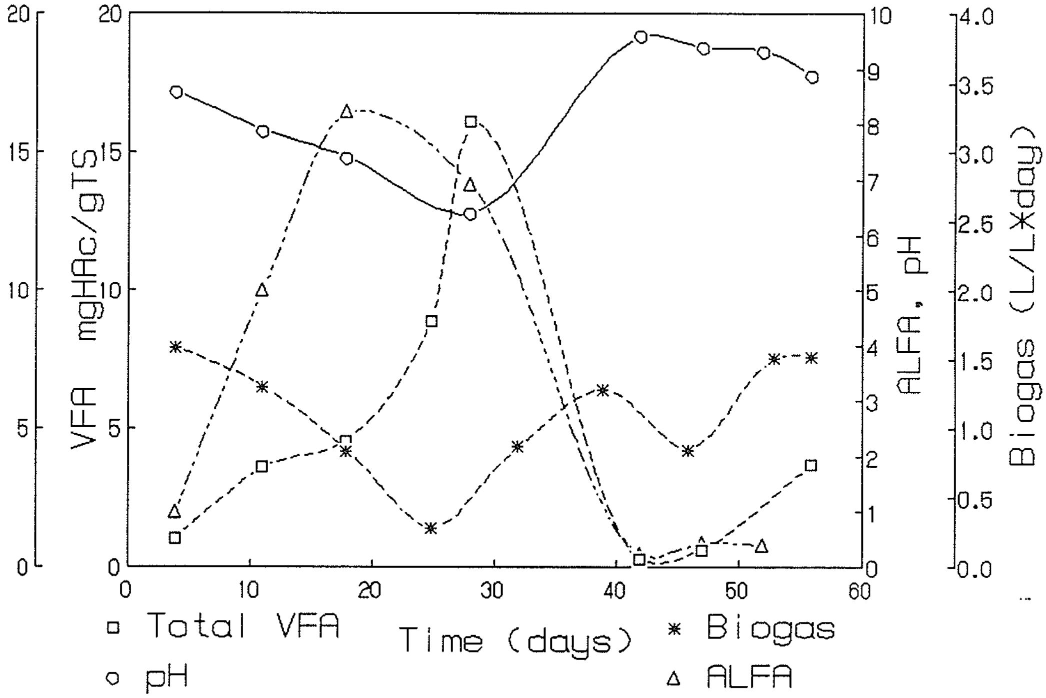


Figure 19: Thermophilic: 30% TS, 15 day RT, R2

In Figure 14 at R1 an increase in temperature resulted in higher removal rates at 21 day RT, yet lower removal rates at 15 day RT. The reverse, however, was true for R2. A decrease in volumetric removal rate was observed at 21 day RT, and a significant increase was seen at 15 day RT, R2.

Comparing the effect of temperature on VFA concentration, the results were more conclusive; see Figure 17. An increase in temperature decreased the VFA level, excepting the case of 15 day RT, R2 where retention time and ratio seemed to be have a strong negative effect.

From this study, it is speculated that the thermophilic methanogenic bacteria were more sensitive to the intermittent feeding procedure, lower retention time and/or high cellulosic feed or a combination of the above. Figures 18 and 19, both 30% TS 15 day RT, performed quite differently. The digester M5, ratio 1 represented in Figure 18 was much more stable having never failed. Its responses were more stable than the thermophilic digester, T4 ratio 2, of Figure 19. T4 failed, requiring reseeding on day 25.

While thermophilic digesters at 21 day retention times showed impressive results, caution must be taken. In full scale, both process stability and flexibility are required to withstand changes in substrate quality and variations in loading rates. These operational factors, along with cost, must be taken into account.

4.3 Ratio

The effect of ratio, that is the fraction of WSS present in the OMSW was significant to biogas production and volumetric removal rate (VRR), as shown in Figures 9 and 14. At 30 to 35% TS, thermophilic R1 biogas production exceeded thermophilic R2 by nearly 30%. The differences between mesophilic R1 and R2 are less clear. Ratio 1 displayed an optimum at 25% TS, followed by a decreasing linear effect. Ratio 2 displayed a quadratic optimum at 35% TS. In this study R2 had nearly one-third higher biogas production than R1 in the mesophilic range at 35% TS, but the R1 digesters were more consistent and stable. Table 8 shows the total nitrogen and phosphorous present in the feed. Recalling that R2 had nearly 50% less WSS than R1, it is evident that nutrients came from both the WSS and OMSW. Less than 10% of the TKN (total Kjeldahl nitrogen) came from the OMSW per unit mass. The phosphorous was almost solely derived from the WSS. Ratio, as an indicator of nutrients present, played a role in the performance of the digester. Overall, the operational stability of R1 was greater. WSS is speculated to have supplied nutrients to the microorganisms essential to the degradation process. The VFA contents were nearly 20% higher in R2 digesters, shown in Figure 5. One could speculate that at ratio 2, i.e. higher MSW:WSS, the VFA was greater due to fewer nutrients and more cellulosic supply resulting in a more stressed microbial development.

| | TKN mg N/gTS | Total Phosphorous mg P/gTS |
|---|---|---|
| Ratio 1 | 3.75 | 0.89 |
| Ratio 2 | 2.82 | 0.58 |

Nutrient test performed on feed samples 25% TS

Table 8: Feed Nutrient Content

Biomass composition has been described by McCarty as $C_{60}H_{87}O_{23}N_{12}P$. The requirements for nitrogen and phosphorous can then be approximated by the fraction present times the biomass growth. In order for synthesis of new cell growth to proceed, the substrate must contain adequate supply of all the elements which are found in the cytoplasmic material of the cell (Benefield and Randall, 1980). Because the OMSW:WSS substrate was defecient in N and P microbial activity was inhibited.

COD tests indicated that the feed contained approximately 1.1 g COD/gTS. This translates to a COD/N of 300 and 400 for R1 and R2 respectively, indicating nutrient deficiencies. More WSS could be added, if available, to lower COD/N/P ratio and possibly improve digester performance.

4.4 Retention Time

The effects of retention time have been mentioned throughout the discussion of the other parameters. As can be seen in the preceding figures, a longer retention lead to greater process stability and better performance. Figure 6 shows that, on average, an increase in RT from 15 to 21 days lead to more than double the efficiency from 17.6% to 40.1%. Biogas productivity was increased nearly 65% with the increase in retention time.

The 15 day RT reactors exhibited a higher level of upsets. The average VFA concentration was 5 times greater at 15 days than at 21 days. The effect of retention time is highly significant. A MRT of two weeks claimed by some researchers and processors is not suitable for this situation. A higher MRT is needed to attain reasonable stabilization, efficiencies and reliable operation.

Graindorge and his colleagues came to the conclusion that lengthening the retention time from 17 to 25 days did not improve degredation. This study concurs with most researchers mentioned in the literature review. The MRT has been found to be a significant operational parameter with an optimal retention time near 3 weeks.

4.5 Dynamic Monitoring

Methane content has shown to change only slightly with widely varying digester performance, similar to that experienced by Graindorge et al. (1989). Therefore, methane content was considered to be a poor choice to monitor the health of a digester. In this study, alfa was found suitable for dynamic monitoring. Alfa is defined as:

$$\text{alfa} = \frac{\text{Intermediate Alkalinity (pH 5.75 to 4.20)}}{\text{Partial Alkalinity (initial pH to pH 5.75)}}$$

(Ripley et al., 1986).

An increase in this parameter was related to upcoming stress or failure conditions. As seen in Figure 18 and Figure 19 an increase in VFA was first announced by an increase in alfa. An increase in the alfa parameter can be used to alert remedial action well before an increase in VFA and the resulting decrease in pH and biogas productivity. A low value of alfa indicated a healthy and reliable performance.

## 5.0 CONCLUSIONS

From the present study examining the co-disposal of waste secondary sludge with synthetic OMSW the following conclusions can be made:

1) The effect of total solids was very significant in the removal efficiency of organic matter and in biogas productivity. Optimim removal efficiency and maximum biogas production were observed between 30 and 35% TS.

2) The effect of retention time was highly significant in VFA concentration as well as process reliability. A 15 day mass retention time affected negatively on the removal efficiency and biogas production. A 21 day MRT resulted in lower VFA concentrations as well as a more reliable and efficient operation.

3) The highest removal efficiencies and biogas production were exhibited by the thermophilic digesters with 21 day RT. The shorter 15 day RT was unstable at the thermophilic operating temperature. Overall, the mesophilic operating temperature was shown to provide greater stability and dependability.

4) Lower MSW:WSS ratio provided microorganisms with more essential nutrients. Digesters fed with ratio 1 MSW:WSS displayed higher removal efficiencies and biogas productivity as well as a lower average VFA concentration.

5) Methane gas content decreased only slightly with decreases in digester performance and was not useful in monitoring the health of the digester.

6) The alfa parameter was an early warning indicator of pending upset or failure.

From the preceding discussion and above conclusions, it is recommended that in the high solids anaerobic digestion of WSS with OMSW that the following parameters be used:

- total solids content of 30 to 35% TS
- mass retention time near 21 days
- a ratio rich in sewage sludge
- mesophilic digesters operating at a temperature of 39 $^{o}$C to 41 $^{o}$C.

This set of conditions may be conservative due to the nature of the designed experiment. The operating parameters however will ensure both process flexibility along with reliability and stability in the co-disposal of waste secondary sludge with organic municipal solid waste.

ABBREVIATIONS

| | |
|---|---|
| ANOVA | Analysis of variance |
| BG | Biogas |
| COD | Chemical Oxygen Demand |
| DAD | Dry anaerobic digestion |
| DEXP | Experimental design |
| F.I.D | Flame Ionization Detector |
| HAc | Acetic acid |
| MRT | Mass retention time, days |
| MSW | Municipal solid waste |
| OMSW | Organic fraction of municipal solid waste |
| R | Ratio |
| r | reactor |
| RR | Removal rate, gVSremoved/kgVScontents*day |
| RT | Retention Time |
| T | Temperature, °C |
| TS | Total solids, % of total weight |
| VFA | Volatile fatty acids, mg HAc/gTS |
| VRR | Volumetric removal rate, gVSremoved/Lwv*day |
| VS | Volatile Solids |
| WSS | waste secondary sludge |
| wv | working volume of the reactor |
| w/v | weight per unit volume |
| w/w | weight per unit weight |

## REFERENCES


Ali Khan, M.Z., and Burney, F.A., Forecasting Solid Waste Composition - An Important Consideration in Resouce Recovery and Recycling. Resources Conservation and Recycling **3** 1-17 (1989).

A.P.H.A. Standard Methods for the Examinationof Water and Wastewater, 16th Edition, A.P.H.A. Washington, D.C. (1985).

Benefield, L.D., and Randall, C.W., Biological Process Design for Wastewater Treatment, Prentice-Hall Inc., Toronto (1980).

Bonomo, L., and Higginson, A.E., "International Overview on Solid Waste Management". Acedemic Press (1988).

Buivid, M.G., Wise, D.L., Blanchet, M.J., Remedios, E.C., Jenkins, B.M., Boyd, W.F., and Pacey, J.G., Fuel Gas Enhancement by Controlled Landfilling of Municipal Solid Waste. Resouces Conserv. **6** 3-20 (1981).

Cayrol, F., Claquin, C., and Peillex, J.P., Anaerobic Digestion of Municipal Solid Waste by the Valorga Process. I.S.W.A Sept. (1988).

Cayrol, F., Peillex, J.P., and Desbois, S., Industrial Application of the Valorga Process for the Treatment of Household Wastes of the City of Amiens. Lisboune, Sept. (1989).

Cecchi, F., Traverso, P.G., Perin, G., and Vallini, G., Comparison of Co-digestion Performance of Two Diferently Collected Organic Fractions of Municipal Solid Wastes with Sewage Sludges. Environmental Technology Letters Vol. 9 391-400 (1988).

Chandler, J.A., Jewell, W.J., Gosset, J.M., Van Soest, P.J., and Robertson, J.B., Predicting Methane Fermentation Biodegradability. Biotech. Bioeng. Symp. **10** 93-107 (1980).

Chynoweth, D.P., and Legrand, R., Anaerobic Digestion as an Integral Part of Municipal Waste Management. Proceedings from International Conference on Landfill Gas and Anaerobic Digestion of Solid Waste. Chester, England. Oct. (1988).

Cooney, C.L., and Wise, D.L., Thermophilic Anaerobic Digestion of Solid Waste for Fuel Gas Production. Biotechnol Bioeng. **17** 1199-1133 (1975).

DeBaere, L., Van Meenan, P., Verstraete, W., Anaerobic Fermentation of Refuse. Proceeding from Materials and Energy from Refuse (1987).

DeBaere, L., Verdonck, O., Verstrate, W., High Rate Dry Anaerobic Composting Process for the Organic Fraction of Solid Wastes. Biotechnology and Bioengineering Symp. **15** (1985).

DeBoosere, S., DeBaere, L., Smis, J., Six, W., Verstraete, W., Dry Anaerobic Fermentation of Concentrated Substrates. Aquatech Water Treatment Conference, Rai Halls, Amsterdam, The Netherlands (1986).

Duarte, A.C., and Anderson, G.K., Inhibition Modelling in Anaerobic Digestion. Wat. Sci. and Tech. **14** (6/7) 749-763 (1982).

Graindorge, P., Cayrol, F., Pavia, A., Methane Fermentation of Urban Waste with a High Paper Content. I.G.T Conference, France Feb. (1989).

Hartz, K.E., Klink, R.E., Ham, R.K., Temperature Effects: Methane Generation from Landfill Samples. J. Environ. Eng. Div. (ASCE) **108** 629-638 (1982).

Haug, R.T., Compost Engineering: Principles and Practice. Ann-Arbor Science Publishers Inc. Mich. USA (1980).

Hicks, C.R., Fundamental Concepts in the Design of Experiments, 3rd Edition. Holt, Rhinehart, and Winston New York (1982).

Hill, D.J., Methane Gas Production from Dairy Manure at High Solids Concentrations. ASAE **23** No. 1, 122-126 (1980a).

Hills, D.J., Biogas from a High Solids Combination of Dairy Manure and Barley Straw. ASAE **23** No. 6, 1550-1504 (1980b).

Hobson, P.N., Bousfield, S., Summers, R., Methane Production From Agricultural and Domestic Wastes. Applied Science Publishers Ltd. Great Britain (1981).

Jewell, W.J., Chandler, J.A., Dell'Orto, S., Fanfoni, K.J., Fast, S., Jackson, D., Kabrick, R.M., Dry Fermentation of Agricultural Residues. Solar Energy Research Institute, U.S.A. (1981).

Kasali, G.B., Senior, E., Watson-Craik, I.A., Sodium Bicarbonate Effects on the Anaerobic Digestion of Refuse. J. Chem. Tech. Biotechnol. **45** 279-289 (1989a).

Kasali, G.B., Senior, E., Watson-Craik, I.A., Preliminary Investigation of the Influence of pH on the Solid State Refuse Methanogenic Fermentation. J. Appl. Bacteriol. **65** 231-239 (1989b).

Kasali, G.B., and Senior, E., Effects of Temperature and Moisture on the Anaerobic Digestion of Refuse. J. Chem. Tech. Biotechnol. **44** 31-41 (1989).

Kimchie, S., Tarre, S., Lumbroso, E., and Green, M., Developments in Anaerobic Digestion of Organic Wastes in Israel. Biological Wastes **26** 275-284 (1988).

Mao, M.C., and Pohland, F.G., Continuing Investigations on Landfill Stabilization with Leachate Recirculation, Neutralization, and Sludge. Special Research Report, Dept. of Civil Engineering, Georgia Institute of Technology, Atlanta (1973).

Marchaim, U. and Creden, J., Research and Development in the Utilization of Agricultural Wastes in Israel for Energy, Feedstock, Fodder and Industrial Products. Fuel Gas Production from Biomass Vol 1, ed. D. Wise CRC Press, Boca Raton, FL. 95-120 (1980).

Mata-Alvarez, J. and Martinez-Viturtia, A. Laboratory Simulation of Municipal Solid Waste Fermentation with Leachate Recycle. J. Chem. Tech. Biotechnol. **36**, 547-556 (1986).

Metcalf and Eddy Inc. Wastewater Engineering: Treatment Disposal and Reuse. McGraw-Hill Book Company, U.S.A. (1979).

Montgomery, D.C., Design and Analysis of Experiments, 2$^{nd}$ Edition. J. Wiley, U.S.A. pp325-355 (1884).

Oremland, R.S., Marsh, L.M., and Polan, S., Methane Production and Simultaneous Sulphate Reduction in Anoxic Salt-Marsh Sediments. Nature (London) **296** 1243-145 (1982).

Parkin, G.F., and Owen, W.F., Fundamentals of Anaerobic Digestion of Wastewater Sludges. J. Env. Eng. ASAE. **112** No. 5 Oct. 867-914 (1986).

Pfeffer, J.T., Anaerobic Digestion Processes. Presented at the First Symposium on Anaerobic Digestion. Cardiff, Wales. Sept. (1979).

Pfeffer, J., Processing Organic Solids by Anaerobic Fermentation, Proceedings of the International Biogas Conference, Biomass Energy Institute, Winnipeg, Canada (1973).

Poggi, H., Heinrichs, D., and Tingley, J., Laboratory Technique Manual for Dry Digestion Studies, University of Manitoba, Winnipeg, Canada (1989).

Poggi-Viraldo, H.M., Heinrichs, D.M., and Oleszkiewicz, J.A., Dry Anaerobic Co-composting of Waste Sludge and Municipal Solid Waste. Presented at the CSCE 1990 Annual Conference, Hamilton, Ontario. May (1990).

Price, R.T., and Cheremisinoff, P.N., Biogas: Production and Utilization. Ann-Arbor Science Publishers Inc. Mich. USA (1981).

Ripley, L.E., Boyle, W.C., and Converse, J.C., Improved Alkilimetric Monitoring for Anaerobic Digestion of High Strength Wastes. J. Wat. Poll. Con. Fed. **58** No. 5 406-411 (1986).

Schmidell, W., Craverso, A.M., Peres, C.S., Hirata, Y.S., and Varella, R.F., Anaerobic Digestion of Municipal Solid Wastes. Wat. Sci. Tech. **18** No. 12 163-175 (1986).

Six, W., and DeBaere, L., Dry Anaerobic Composting of Various Organic Wastes. Fifth International Symposium on Anaerobic Digestion Bologna, Italy (1988).

Ten Brummeler, E. and Koster, I.W., The Effect of Several pH Control Chemicals on the Dry Batch Digestion of the Organic Fraction of Municipal Solid Waste. Resources Conservation and Recycling **3** 19-32 (1989).

Ten Brummeler, E., Koster, I.W., and Zeevalkink, J.A., Dry Digestion of the Organic Fraction of Municipal Solid Waste in a Batch Process. International Symp. Anaer. Dig., Bologne, Italia (1988).

Wujcik, W.J. Dry Anaerobic Fermentation to Methane of Organic Residues. Ph. D. Thesis, Cornell University (1980).

Wujcik, W.J. and Jewell, W.J. Dry Anaerobic Fermentation Biotechnol. Bioeng. Symp. **10** 43 43-65 Oct.(1980).

**APPENDIX A**

**FEEDING NOTATIONS**

| Reactor | Target Mass kg | Feed Mass g* | Feed Mass g** |
|---|---|---|---|
| M0 | 0.9 | 210 | 280 |
| M1 | 0.5 | 83 | 111 |
| M2 | 0.5 | 117 | 156 |
| M3 | 0.4 | 67 | 89 |
| M4 | 0.4 | 93 | 124 |
| M5 | 0.5 | 117 | 156 |
| M6 | 0.5 | 117 | 156 |
| M7 | 0.5 | 83 | 111 |
| M8 | 0.5 | 83 | 111 |
| M9 | 0.6 | 140 | 187 |
| T0 | 0.9 | 150 | 200 |
| T1 | 0.5 | 83 | 111 |
| T2 | 0.4 | 93 | 124 |
| T3 | 0.4 | 67 | 89 |
| T4 | 0.5 | 117 | 156 |
| T5 | 0.5 | 83 | 111 |
| T6 | 0.5 | 117 | 156 |
| T7 | 0.5 | 117 | 156 |
| T8 | 0.5 | 83 | 111 |
| T9 | 0.6 | 140 | 187 |

* feeding schedule twice per week preceding July 25/89

** feeding schedule three time per two weeks following July 25/89.

SODIUM BICARBONATE AND RESEEDING

| | | |
|---|---|---|
| July 7 | T7 | 100g of T0 |
| July 12 | M4 | 0.5g Bic. |
| July 14 | M4 | 2g Bic. + 34g M3 + 50g M7 |
| July 18 | T2 | 2g Bic. + 93g T0 |
| July 25 | M0 | 3.6g Bic. |
| | M3 | 0.8g Bic. |
| | M4 | 0.8g Bic. |
| | M6 | 1g Bic. |
| | T4 | 2g Bic. |
| | T6 | 2g Bic. |
| July 28 | M0 | 1g Bic. |
| | M4 | 4g Bic. |
| | T4 | 2g Bic. + 80g T0 |
| | T5 | 2g Bic. + 70.3g T0 |
| | T6 | 2g Bic. |
| Aug. 2 | M2 | 2g Bic. + 137.2 M0 |
| | M4 | 2g Bic. |
| | M6 | 3g Bic. |
| Aug. 7 | M0 | 0.5g Bic. |
| | M1 | 0.5g Bic. |
| | M2 | 2g Bic. + 156g M0 |
| | M3 | 0.5g Bic. |
| | M4 | 79g M7 + 41g M0 |
| | M5 | 0.5g Bic. |
| | M6 | 2g Bic. |
| | M7 | 0.5g Bic. |
| | T2 | 1g Bic. + 56g T3 |
| | T9 | 0.5g Bic. |
| Aug. 11 | M0 | 5.6 Bic. |
| | M5 | 0.5 Bic. |
| | M6 | 0.5g Bic. |
| | M7 | 0.5g Bic. |
| | M8 | 0.5g Bic. |
| | M9 | 0.5g Bic. |
| | T2 | 3.6g Bic. + 111g T0 |
| | T3 | 1g Bic. |
| | T8 | 0.5g Bic. |

| | | |
|---|---|---|
| Aug. 16 | M0 | 3.6g Bic. |
| | M2 | 151.3g M |
| | M3 | 0.5g Bic. |
| | M4 | 79.6g M |
| | M5 | 0.5g Bic. |
| | M6 | 1g Bic. |
| | M7 | 0.5g Bic. |
| | M8 | 2g Bic. |
| | M9 | 2.4g Bic. |
| | T2 | 77.4 T. |
| | T3 | 1g Bic. |
| | T8 | 0.5g Bic. |

Aug. 21 restart T2: 100g T2 + 183g T0 + 46g T3 + 72g T1

| | | |
|---|---|---|
| | M0 | 1.4g Bic. |
| | M1 | 0.33g Bic. |
| | M2 | 0.47c Bic. |
| | M3 | 0.27g Bic. |
| | M4 | 0.37g Bic. |
| | M5 | 0.47g Bic. |
| | M6 | 0.78g Bic. |
| | M7 | 0.56g Bic. |
| | M8 | 0.56g Bic. |
| | M9 | 0.56g Bic. |
| | T0 | 0.60g Bic. |
| | T1 | 0.11g Bic. |
| | T2 | 0.62g Bic. |
| | T3 | 0.44g Bic. |
| | T4 | 0.47g Bic. |
| | T5 | 0.33g Bic. |
| | T6 | 0.78g Bic. |
| | T7 | 0.47g Bic. |
| | T8 | 0.33g Bic. |
| | T9 | 0.56g Bic. |

**APPENDIX B**

OPERATIONAL DATA

B1: PERFORMANCE DATA

| SAMPLE | Mass of Reactor (kg) | Retention Time days | Ratio | Nominal Total Solids % | Average Total Solids % | Mass of Reactor (kgTS) | Mass of Reactor (kgVS) | Bulk Density (kg/L) | Digest Volume (L) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.9 | 15 | 2 | 30 | 27.55 | 0.248 | 0.235 | 0.428 | 2.10 |
| M1 | 0.5 | 21 | 1 | 25 | 24.95 | 0.125 | 0.118 | 0.466 | 1.07 |
| M2 | 0.5 | 15 | 2 | 25 | 23.59 | 0.118 | 0.114 | 0.487 | 1.03 |
| M3 | 0.4 | 21 | 1 | 40 | 39.09 | 0.156 | 0.149 | 0.257 | 1.56 |
| M4 | 0.4 | 15 | 2 | 40 | 37.05 | 0.148 | 0.144 | 0.287 | 1.39 |
| M5 | 0.5 | 15 | 1 | 30 | 28.28 | 0.141 | 0.134 | 0.417 | 1.20 |
| M6 | 0.5 | 15 | 1 | 35 | 33.91 | 0.170 | 0.161 | 0.334 | 1.50 |
| M7 | 0.5 | 21 | 2 | 35 | 32.65 | 0.163 | 0.159 | 0.353 | 1.42 |
| M8 | 0.5 | 21 | 2 | 30 | 28.47 | 0.142 | 0.138 | 0.414 | 1.21 |
| M9 | 0.6 | 15 | 2 | 20 | 18.83 | 0.113 | 0.110 | 0.557 | 1.08 |
| T0 | 0.9 | 21 | 2 | 30 | 27.45 | 0.247 | 0.240 | 0.429 | 2.10 |
| T1 | 0.5 | 21 | 1 | 30 | 28.66 | 0.143 | 0.136 | 0.412 | 1.22 |
| T2 | 0.4 | 15 | 1 | 40 | 37.69 | 0.151 | 0.143 | 0.278 | 1.44 |
| T3 | 0.4 | 21 | 2 | 40 | 36.78 | 0.147 | 0.143 | 0.291 | 1.37 |
| T4 | 0.5 | 15 | 2 | 30 | 27.69 | 0.138 | 0.135 | 0.426 | 1.17 |
| T5 | 0.5 | 21 | 1 | 35 | 31.63 | 0.158 | 0.150 | 0.368 | 1.36 |
| T6 | 0.5 | 15 | 2 | 35 | 31.72 | 0.159 | 0.154 | 0.366 | 1.37 |
| T7 | 0.5 | 15 | 1 | 25 | 25.50 | 0.127 | 0.121 | 0.458 | 1.09 |
| T8 | 0.5 | 21 | 2 | 25 | 23.25 | 0.116 | 0.113 | 0.492 | 1.02 |
| T9 | 0.6 | 15 | 2 | 20 | 19.34 | 0.116 | 0.112 | 0.549 | 1.09 |

| SAMPLE | Input g/day | Input TS g/day | Input VS g/day | JULY AVERAGE (L/day) | AUGUST AVERAGE (L/day) | Jul-Aug AVERAGE (L/day) |
|---|---|---|---|---|---|---|
| M0 | 60.00 | 18.29 | 17.78 | 1.622 | 1.930 | 1.759 |
| M1 | 23.81 | 5.30 | 5.01 | 1.359 | 1.399 | 1.377 |
| M2 | 33.33 | 6.87 | 6.42 | 1.067 | 0.138 | 0.654 |
| M3 | 19.05 | 6.72 | 6.32 | 1.288 | 1.238 | 1.266 |
| M4 | 26.67 | 8.23 | 7.86 | 1.199 | 0.140 | 0.728 |
| M5 | 33.33 | 8.67 | 8.19 | 1.707 | 1.374 | 1.559 |
| M6 | 33.33 | 9.99 | 9.38 | 1.341 | 1.505 | 1.414 |
| M7 | 23.81 | 7.06 | 6.84 | 2.129 | 2.443 | 2.269 |
| M8 | 23.81 | 6.19 | 5.99 | 1.631 | 1.311 | 1.489 |
| M9 | 40.00 | 8.18 | 7.89 | 1.676 | 1.347 | 1.530 |
| T0 | 42.86 | 13.07 | 12.70 | 2.382 | 1.789 | 2.118 |
| T1 | 23.81 | 6.13 | 5.81 | 2.057 | 2.052 | 2.055 |
| T2 | 26.67 | 9.06 | 8.63 | 0.742 | 0.054 | 0.436 |
| T3 | 19.05 | 6.29 | 6.07 | 1.096 | 0.939 | 1.026 |
| T4 | 33.33 | 8.39 | 8.11 | 1.149 | 1.517 | 1.313 |
| T5 | 23.81 | 7.07 | 6.65 | 2.563 | 2.954 | 2.737 |
| T6 | 33.33 | 9.54 | 9.21 | 1.253 | 2.133 | 1.644 |
| T7 | 33.33 | 7.48 | 7.08 | 1.489 | 1.567 | 1.524 |
| T8 | 23.81 | 5.32 | 5.15 | 1.295 | 1.644 | 1.450 |
| T9 | 40.00 | 8.18 | 7.89 | 1.817 | 1.648 | 1.742 |

| SAMPLE | (Yield= 0.72 m^3/kgVS rem.) JULY Efficiency | AUGUST Efficiency | Jul-Aug Efficiency | Volumetric Loading Rate (gVSfed/ Lwv*d) | Mass Loading Rate (gVSfed/ kgMass*d) | (gVSfed/ kgMvs*d) |
|---|---|---|---|---|---|---|
| M0 | 0.127 | 0.151 | 0.137 | 8.46 | 19.76 | 75.75 |
| M1 | 0.377 | 0.388 | 0.382 | 4.67 | 10.02 | 42.42 |
| M2 | 0.231 | 0.030 | 0.141 | 6.25 | 12.84 | 56.18 |
| M3 | 0.283 | 0.272 | 0.278 | 4.06 | 15.80 | 42.52 |
| M4 | 0.212 | 0.025 | 0.129 | 5.64 | 19.65 | 54.55 |
| M5 | 0.289 | 0.233 | 0.264 | 6.83 | 16.38 | 61.13 |
| M6 | 0.199 | 0.223 | 0.209 | 6.26 | 18.76 | 58.33 |
| M7 | 0.432 | 0.496 | 0.461 | 4.82 | 13.68 | 43.10 |
| M8 | 0.378 | 0.304 | 0.345 | 4.96 | 11.98 | 43.30 |
| M9 | 0.295 | 0.237 | 0.269 | 7.33 | 13.15 | 71.86 |
| T0 | 0.261 | 0.196 | 0.232 | 6.05 | 14.11 | 52.89 |
| T1 | 0.492 | 0.491 | 0.491 | 4.78 | 11.62 | 42.79 |
| T2 | 0.119 | 0.009 | 0.070 | 6.00 | 21.58 | 60.23 |
| T3 | 0.251 | 0.215 | 0.235 | 4.42 | 15.18 | 42.44 |
| T4 | 0.197 | 0.260 | 0.225 | 6.91 | 16.22 | 60.28 |
| T5 | 0.535 | 0.617 | 0.572 | 4.89 | 13.30 | 44.34 |
| T6 | 0.189 | 0.322 | 0.248 | 6.75 | 18.42 | 59.73 |
| T7 | 0.292 | 0.307 | 0.299 | 6.49 | 14.16 | 58.67 |
| T8 | 0.349 | 0.443 | 0.391 | 5.06 | 10.30 | 45.72 |
| T9 | 0.320 | 0.290 | 0.307 | 7.22 | 13.15 | 70.18 |

| SAMPLE | July Removal Rate (gVS/kgVS*d) | August | Jul-Aug | July Volumetric Removal Rate (gVS/Lwv*d) | August | Jul-Aug |
|---|---|---|---|---|---|---|
| M0 | 9.598 | 11.421 | 10.408 | 1.071 | 1.275 | 1.162 |
| M1 | 15.985 | 16.452 | 16.192 | 1.759 | 1.811 | 1.782 |
| M2 | 12.965 | 1.672 | 7.946 | 1.442 | 0.186 | 0.884 |
| M3 | 12.035 | 11.570 | 11.828 | 1.149 | 1.105 | 1.130 |
| M4 | 11.556 | 1.346 | 7.018 | 1.195 | 0.139 | 0.726 |
| M5 | 17.693 | 14.241 | 16.159 | 1.977 | 1.591 | 1.806 |
| M6 | 11.581 | 12.998 | 12.211 | 1.244 | 1.396 | 1.311 |
| M7 | 18.633 | 21.379 | 19.854 | 2.085 | 2.393 | 2.222 |
| M8 | 16.374 | 13.165 | 14.948 | 1.876 | 1.508 | 1.712 |
| M9 | 21.199 | 17.030 | 19.346 | 2.161 | 1.736 | 1.972 |
| T0 | 13.779 | 10.344 | 12.253 | 1.577 | 1.184 | 1.402 |
| T1 | 21.041 | 20.993 | 21.020 | 2.351 | 2.346 | 2.349 |
| T2 | 7.189 | 0.520 | 4.225 | 0.716 | 0.052 | 0.421 |
| T3 | 10.642 | 9.120 | 9.965 | 1.107 | 0.949 | 1.037 |
| T4 | 11.865 | 15.659 | 13.551 | 1.360 | 1.795 | 1.553 |
| T5 | 23.731 | 27.351 | 25.340 | 2.620 | 3.019 | 2.797 |
| T6 | 11.288 | 19.215 | 14.811 | 1.275 | 2.171 | 1.673 |
| T7 | 17.138 | 18.039 | 17.539 | 1.896 | 1.996 | 1.940 |
| T8 | 15.972 | 20.269 | 17.882 | 1.769 | 2.245 | 1.981 |
| T9 | 22.444 | 20.350 | 21.513 | 2.309 | 2.094 | 2.213 |

| SAMPLE | JULY AVERAGE Yield (m^3BG/ kg.fed) | Yield (m^3BG/ kgTSfed) | Yield (m^3BG/ kgVSfed) | AUGUST AVERAGE Yield (m^3BG/ kg.fed) | Yield (m^3BG/ kgTSfed) | Yield (m^3BG/ kgVSfed) | JUL-AUG AVERAGE Yield (m^3BG/ kg.fed) | Yield (m^3BG/ kgTSfed) | Yield (m^3BG/ kgVSfed) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.027 | 0.089 | 0.091 | 0.032 | 0.106 | 0.109 | 0.029 | 0.096 | 0.099 |
| M1 | 0.057 | 0.256 | 0.271 | 0.059 | 0.264 | 0.279 | 0.058 | 0.260 | 0.275 |
| M2 | 0.032 | 0.155 | 0.166 | 0.004 | 0.020 | 0.021 | 0.020 | 0.095 | 0.102 |
| M3 | 0.068 | 0.192 | 0.204 | 0.065 | 0.184 | 0.196 | 0.066 | 0.188 | 0.200 |
| M4 | 0.045 | 0.146 | 0.153 | 0.005 | 0.017 | 0.018 | 0.027 | 0.088 | 0.093 |
| M5 | 0.051 | 0.197 | 0.208 | 0.041 | 0.158 | 0.168 | 0.047 | 0.180 | 0.190 |
| M6 | 0.040 | 0.134 | 0.143 | 0.045 | 0.151 | 0.160 | 0.042 | 0.142 | 0.151 |
| M7 | 0.089 | 0.302 | 0.311 | 0.103 | 0.346 | 0.357 | 0.095 | 0.321 | 0.332 |
| M8 | 0.069 | 0.263 | 0.272 | 0.055 | 0.212 | 0.219 | 0.063 | 0.241 | 0.249 |
| M9 | 0.042 | 0.205 | 0.212 | 0.034 | 0.165 | 0.171 | 0.038 | 0.187 | 0.194 |
| T0 | 0.056 | 0.182 | 0.188 | 0.042 | 0.137 | 0.141 | 0.049 | 0.162 | 0.167 |
| T1 | 0.086 | 0.336 | 0.354 | 0.086 | 0.335 | 0.353 | 0.086 | 0.335 | 0.354 |
| T2 | 0.028 | 0.082 | 0.086 | 0.002 | 0.006 | 0.006 | 0.016 | 0.048 | 0.051 |
| T3 | 0.058 | 0.174 | 0.181 | 0.049 | 0.149 | 0.155 | 0.054 | 0.163 | 0.169 |
| T4 | 0.034 | 0.137 | 0.142 | 0.046 | 0.181 | 0.187 | 0.039 | 0.156 | 0.162 |
| T5 | 0.108 | 0.362 | 0.385 | 0.124 | 0.418 | 0.444 | 0.115 | 0.387 | 0.412 |
| T6 | 0.038 | 0.131 | 0.136 | 0.064 | 0.224 | 0.232 | 0.049 | 0.172 | 0.179 |
| T7 | 0.045 | 0.199 | 0.210 | 0.047 | 0.210 | 0.221 | 0.046 | 0.204 | 0.215 |
| T8 | 0.054 | 0.244 | 0.252 | 0.069 | 0.309 | 0.319 | 0.061 | 0.273 | 0.282 |
| T9 | 0.045 | 0.222 | 0.230 | 0.041 | 0.201 | 0.209 | 0.044 | 0.213 | 0.221 |

| JUL-AUG 1989 Sample | VFA as HAc (mg/g) 4/7 | VFA as HAc (mg/g) 11/7 | VFA as HAc (mg/g) 18/7 | VFA as HAc (mg/g) 25/7 | VFA as HAc (mg/g) 28/7 | VFA as HAc (mg/g) 11/8 | VFA as HAc (mg/g) 16.7 | VFA as HAc (mg/g) 25/8 | Average 4/7-25/8 VFA as HAc (mg/g) | Std. Dev. 4/7-25/8 VFA as HAc (mg/g) |
|---|---|---|---|---|---|---|---|---|---|---|
| M0 | 1.32 | 0.02 | 1.80 | 2.51 | 4.85 | | 4.02 | 16.03 | 4.36 | 5.00 |
| M1 | 0.31 | 0.96 | 0.99 | 0.33 | 0.58 | | 0.48 | 0.46 | 0.56 | 0.24 |
| M2 | 0.84 | 0.37 | 0.54 | [illegible] | 1.13 | | 0.00 | 2.23 | 0.78 | 0.68 |
| M3 | 0.81 | 0.45 | 0.66 | 0.33 | 2.50 | | 1.18 | 3.82 | 1.39 | 1.20 |
| M4 | 1.29 | 0.59 | | 8.28 | 10.66 | | 4.63 | 9.38 | 5.81 | 3.90 |
| M5 | 0.54 | 0.32 | 0.59 | 0.34 | 3.40 | | 2.01 | 7.04 | 2.04 | 2.30 |
| M6 | 1.14 | 1.22 | 1.53 | 2.30 | 4.13 | | 5.42 | 13.20 | 4.13 | 3.99 |
| M7 | 0.59 | 0.73 | 0.31 | | 0.58 | | 0.14 | 1.05 | 0.63 | 0.27 |
| M8 | 0.72 | 0.92 | 0.90 | 0.27 | 0.43 | | 0.49 | 2.27 | 0.86 | 0.62 |
| M9 | 0.59 | 0.94 | 0.98 | | 0.89 | | 1.67 | 9.01 | 2.35 | 3.00 |
| | | | | | | | | | | |
| T0 | 0.27 | 0.63 | 0.45 | | 0.67 | 1.51 | 0.06 | 4.48 | 1.15 | 1.42 |
| T1 | 0.70 | 0.23 | 0.25 | | 0.62 | 0.42 | 0.53 | 0.00 | 0.41 | 0.24 |
| T2 | 2.06 | 3.08 | 5.20 | 3.06 | | 4.17 | 2.71 | 3.00 | 3.33 | 0.96 |
| T3 | 1.16 | 0.54 | 1.27 | 0.77 | 0.78 | 0.00 | 1.07 | 1.92 | 0.95 | 0.52 |
| T4 | 1.09 | 3.62 | 4.59 | 8.92 | 16.15 | 0.30 | 0.67 | 3.77 | 4.89 | 4.99 |
| T5 | 0.00 | 0.36 | 3.74 | | 0.48 | 0.54 | 0.05 | 0.54 | 0.82 | 1.21 |
| T6 | 0.65 | 3.89 | 6.53 | | 16.84 | 0.46 | 0.73 | 1.98 | 4.44 | 5.46 |
| T7 | 0.54 | 0.69 | 0.55 | | 0.57 | 0.21 | 0.03 | 0.83 | 0.49 | 0.26 |
| T8 | 0.66 | 0.19 | 0.00 | 0.63 | 0.46 | 0.27 | | 1.26 | 0.49 | 0.38 |
| T9 | 0.68 | 0.70 | 0.38 | | 0.47 | 0.29 | | 1.38 | 0.65 | 0.36 |
| | | | | | | | | | | |
| F R1;25 | 4.59 | 7.31 | 1.73 | | | | | 0.47 | 3.53 | 2.65 |
| F R1;30 | 6.67 | 5.16 | 2.54 | | | | | 0.72 | 3.77 | 2.30 |
| F R1;35 | 4.05 | 4.66 | 1.58 | | | | | 0.79 | 2.77 | 1.62 |
| F R1;40 | 2.81 | 2.47 | 1.26 | | | | | 0.65 | 1.90 | 0.88 |
| F R2;20 | 7.86 | 9.98 | 4.99 | | | | | 1.46 | 6.07 | 3.20 |
| F R2;25 | 3.51 | 2.91 | 2.39 | | | | | 0.94 | 2.43 | 0.95 |
| F R2;30 | 1.35 | 3.46 | 2.52 | | | | | 0.59 | 1.98 | 1.10 |
| F R2;35 | 3.37 | 5.00 | 2.29 | | | | | 1.20 | 2.96 | 1.41 |
| F R2;40 | 0.22 | 2.79 | 2.77 | | | | | 1.51 | 1.82 | 1.06 |

## B2: BIOGAS PRODUCTIVITY AND COMPOSITION

| SAMPLE | Mass of Reactor (kg) | Nominal Total Solids % | Average Total Solids % | Mass of Reactor (kgTS) | Bulk Density (kg/L) | Digest Volume (L) |
|---|---|---|---|---|---|---|
| M0 | 0.900 | 30 | 27.55 | 0.248 | 0.428 | 2.10 |
| M1 | 0.500 | 25 | 24.95 | 0.125 | 0.466 | 1.07 |
| M2 | 0.500 | 25 | 23.59 | 0.118 | 0.487 | 1.03 |
| M3 | 0.400 | 40 | 39.09 | 0.156 | 0.257 | 1.56 |
| M4 | 0.400 | 40 | 37.05 | 0.148 | 0.287 | 1.39 |
| M5 | 0.500 | 30 | 28.28 | 0.141 | 0.417 | 1.20 |
| M6 | 0.500 | 35 | 33.91 | 0.170 | 0.334 | 1.50 |
| M7 | 0.500 | 35 | 32.65 | 0.163 | 0.353 | 1.42 |
| M8 | 0.500 | 30 | 28.47 | 0.142 | 0.414 | 1.21 |
| M9 | 0.600 | 20 | 18.83 | 0.113 | 0.557 | 1.08 |
| T0 | 0.900 | 30 | 27.45 | 0.247 | 0.429 | 2.10 |
| T1 | 0.500 | 30 | 28.66 | 0.143 | 0.412 | 1.22 |
| T2 | 0.400 | 40 | 37.69 | 0.151 | 0.278 | 1.44 |
| T3 | 0.400 | 40 | 36.78 | 0.147 | 0.291 | 1.37 |
| T4 | 0.500 | 30 | 27.69 | 0.138 | 0.426 | 1.17 |
| T5 | 0.500 | 35 | 31.63 | 0.158 | 0.368 | 1.36 |
| T6 | 0.500 | 35 | 31.72 | 0.159 | 0.366 | 1.37 |
| T7 | 0.500 | 25 | 25.50 | 0.127 | 0.458 | 1.09 |
| T8 | 0.500 | 25 | 23.25 | 0.116 | 0.492 | 1.02 |
| T9 | 0.600 | 20 | 19.34 | 0.116 | 0.549 | 1.09 |

AVERAGE DAILY BIOGAS PRODUCTION PER REACTOR @ STP

| SAMPLE | 28/6-4/7 AVERAGE (L/day) | 5/7-11/7 AVERAGE (L/day) | 12/7-18/7 AVERAGE (L/day) | 19/7-25/7 AVERAGE (L/day) | 26/7-1/8 AVERAGE (L/day) | 2/8-8/8 AVERAGE (L/day) | 9/8-15/8 AVERAGE (L/day) | 16/8-22/8 AVERAGE (L/day) | 23/8-25/8 AVERAGE (L/day) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 1.737 | 1.327 | 1.443 | 1.205 | 1.899 | 1.648 | 1.698 | 2.397 | 1.378 |
| M1 | 1.385 | 1.797 | 1.404 | 0.709 | 1.502 | 1.457 | 1.445 | 1.369 | 1.325 |
| M2 | 1.514 | 2.086 | 0.726 | 0.710 | 0.298 | 0.072 | 0.000 | 0.337 | 0.142 |
| M3 | 1.301 | 1.209 | 1.210 | 1.196 | 1.524 | 1.353 | 1.162 | 1.210 | 1.228 |
| M4 | 1.337 | 1.126 | 1.500 | 1.281 | 0.751 | 0.234 | 0.088 | 0.148 | 0.088 |
| M5 | 1.599 | 1.588 | 1.818 | 1.515 | 1.914 | 1.456 | 1.066 | 1.538 | 1.435 |
| M6 | 1.468 | 1.275 | 1.327 | 1.236 | 1.397 | 1.765 | 1.636 | 1.552 | 1.067 |
| M7 | 1.557 | 1.814 | 2.123 | 2.681 | 2.471 | 2.385 | 2.602 | 2.530 | 2.254 |
| M8 | 1.604 | 1.641 | 1.752 | 1.634 | 1.524 | 1.185 | 1.119 | 1.568 | 1.374 |
| M9 | 1.526 | 1.885 | 1.658 | 1.897 | 1.415 | 1.142 | 0.962 | 1.822 | 1.460 |
| T0 | 2.504 | 2.167 | 1.967 | 2.357 | 2.917 | 2.576 | 1.661 | 1.625 | 1.292 |
| T1 | 1.966 | 2.530 | 2.293 | 1.216 | 2.280 | 2.016 | 2.215 | 2.099 | 1.878 |
| T2 | 1.375 | 1.228 | 0.335 | 0.315 | 0.456 | 0.074 | 0.074 | 0.020 | 0.047 |
| T3 | 1.311 | 1.356 | 1.019 | 0.821 | 0.973 | 0.775 | 0.749 | 1.281 | 0.951 |
| T4 | 1.864 | 1.525 | 0.988 | 0.338 | 1.033 | 1.504 | 1.007 | 1.772 | 1.785 |
| T5 | 2.259 | 2.846 | 2.500 | 2.386 | 2.822 | 3.023 | 3.083 | 3.144 | 2.565 |
| T6 | 2.178 | 1.042 | 1.167 | 0.412 | 1.467 | 2.066 | 1.667 | 2.572 | 2.229 |
| T7 | 1.917 | 1.420 | 1.254 | 1.193 | 1.662 | 1.331 | 1.371 | 1.708 | 1.859 |
| T8 | 1.702 | 1.464 | 1.188 | 1.012 | 1.111 | 1.084 | 0.973 | 2.188 | 2.331 |
| T9 | 1.698 | 2.279 | 1.737 | 1.774 | 1.597 | 1.428 | 1.933 | 1.560 | 1.769 |

| SAMPLE | JULY AVERAGE (L/day) | JULY Std. Dev. (L/day) | AUGUST AVERAGE (L/day) | AUGUST Std. Dev. (L/day) | JUL-AUG AVERAGE (L/day) | JUL-AUG Std. Dev. (L/day) |
|---|---|---|---|---|---|---|
| M0 | 1.622 | 0.260 | 1.930 | 0.297 | 1.759 | 0.317 |
| M1 | 1.359 | 0.357 | 1.399 | 0.055 | 1.377 | 0.269 |
| M2 | 1.067 | 0.644 | 0.138 | 0.125 | 0.654 | 0.671 |
| M3 | 1.288 | 0.124 | 1.238 | 0.071 | 1.266 | 0.107 |
| M4 | 1.199 | 0.254 | 0.140 | 0.059 | 0.728 | 0.561 |
| M5 | 1.707 | 0.144 | 1.374 | 0.182 | 1.559 | 0.232 |
| M6 | 1.341 | 0.084 | 1.505 | 0.264 | 1.414 | 0.204 |
| M7 | 2.129 | 0.412 | 2.443 | 0.134 | 2.269 | 0.356 |
| M8 | 1.631 | 0.073 | 1.311 | 0.175 | 1.489 | 0.205 |
| M9 | 1.676 | 0.192 | 1.347 | 0.327 | 1.530 | 0.308 |
| T0 | 2.382 | 0.323 | 1.789 | 0.477 | 2.118 | 0.496 |
| T1 | 2.057 | 0.457 | 2.052 | 0.123 | 2.055 | 0.351 |
| T2 | 0.742 | 0.462 | 0.054 | 0.022 | 0.436 | 0.485 |
| T3 | 1.096 | 0.205 | 0.939 | 0.212 | 1.026 | 0.222 |
| T4 | 1.149 | 0.520 | 1.517 | 0.315 | 1.313 | 0.477 |
| T5 | 2.563 | 0.234 | 2.954 | 0.228 | 2.737 | 0.302 |
| T6 | 1.253 | 0.576 | 2.133 | 0.325 | 1.644 | 0.650 |
| T7 | 1.489 | 0.268 | 1.567 | 0.223 | 1.524 | 0.252 |
| T8 | 1.295 | 0.253 | 1.644 | 0.619 | 1.450 | 0.486 |
| T9 | 1.817 | 0.238 | 1.548 | 0.162 | 1.742 | 0.224 |

PERCENT METHANE CONTENT

| SAMPLE | 3/7 CH4 % | 6/7 CH4 % | 17/7 CH4 % | 24/7 CH4 % | 27/7 CH4 % | 1/8 CH4 % | 10/8 CH4 % | 15/8 CH4 % |
|---|---|---|---|---|---|---|---|---|
| M0 | 51.0 | 52.9 | 52.1 | 51.2 | 53.2 | 56.3 | 48.6 | 52.6 |
| M1 | 52.8 | 53.0 | 52.2 | 53.3 | 58.7 | 59.2 | 53.8 | 55.7 |
| M2 | 53.8 | 55.6 | 55.3 | 54.3 | 49.2 | 60.2 | 50.1 | 58.0 |
| M3 | 51.9 | 52.9 | 51.2 | 53.2 | 55.2 | 56.4 | 50.7 | 52.7 |
| M4 | 51.3 | 50.7 | 47.0 | 49.3 | 49.6 | 53.5 | 46.3 | 52.4 |
| M5 | 49.4 | 52.9 | 53.8 | 53.9 | 58.3 | 57.4 | 50.4 | 51.6 |
| M6 | 51.1 | 51.9 | 51.7 | 50.6 | 56.6 | 54.0 | 46.1 | 56.2 |
| M7 | 52.2 | 52.9 | 54.3 | 53.8 | 59.1 | 58.2 | 52.2 | 56.3 |
| M8 | 52.8 | 53.6 | 53.8 | 54.4 | 61.8 | 58.4 | 50.8 | 53.6 |
| M9 | 53.3 | 53.9 | 53.1 | 53.3 | 59.1 | 58.4 | 50.4 | 64.7 |
| | | | | | | | | |
| T0 | 54.3 | 55.7 | 55.3 | 54.7 | 59.3 | 60.5 | 53.4 | 52.0 |
| T1 | 51.0 | 53.4 | 53.3 | 53.3 | 58.8 | 59.3 | 52.1 | 55.0 |
| T2 | 52.2 | 51.9 | 46.4 | 42.7 | 58.5 | 57.2 | 46.2 | 50.8 |
| T3 | 53.8 | 54.4 | 53.3 | 54.1 | 58.3 | 58.2 | 50.6 | 54.4 |
| T4 | 52.6 | 53.8 | 52.4 | 10.0 | 22.3 | 65.5 | 59.3 | 55.7 |
| T5 | 53.7 | 54.1 | 53.7 | 54.3 | 62.9 | 60.1 | 52.9 | 55.7 |
| T6 | 52.6 | 50.0 | 47.9 | 7.1 | 9.5 | 62.0 | 61.3 | 54.8 |
| T7 | 52.7 | 51.0 | 55.1 | 57.3 | 60.1 | 59.7 | 52.5 | 54.7 |
| T8 | 53.1 | 54.7 | 54.7 | 54.8 | 61.1 | 60.8 | 44.3 | 56.9 |
| T9 | 55.2 | 54.8 | 54.5 | 53.8 | 60.9 | 60.0 | 56.1 | 57.2 |

| SAMPLE | JULY AVERAGE CH4 % | JULY Std. Dev. CH4 % | AUGUST AVERAGE CH4 % | AUGUST Std. Dev. CH4 % | JUL-AUG AVERAGE CH4 % | JUL-AUG Std. Dev. CH4 % |
|---|---|---|---|---|---|---|
| M0 | 52.1 | 0.880 | 52.5 | 3.144 | 52.2 | 2.057 |
| M1 | 54.0 | 2.375 | 56.2 | 2.237 | 54.8 | 2.563 |
| M2 | 53.6 | 2.307 | 56.1 | 4.337 | 54.6 | 3.435 |
| M3 | 52.9 | 1.362 | 53.3 | 2.361 | 53.0 | 1.813 |
| M4 | 49.6 | 1.483 | 51.4 | 2.238 | 50.3 | 2.006 |
| M5 | 53.7 | 2.838 | 53.1 | 3.057 | 53.5 | 2.933 |
| M6 | 52.4 | 2.157 | 52.1 | 4.337 | 52.3 | 3.159 |
| M7 | 54.5 | 2.421 | 55.6 | 2.504 | 54.9 | 2.509 |
| M8 | 55.3 | 3.302 | 54.3 | 3.138 | 54.9 | 3.278 |
| M9 | 54.5 | 2.296 | 57.8 | 5.852 | 55.8 | 4.322 |
| | | | | | | |
| T0 | 55.9 | 1.786 | 55.3 | 3.721 | 55.7 | 2.694 |
| T1 | 54.0 | 2.574 | 55.5 | 2.958 | 54.5 | 2.819 |
| T2 | 50.3 | 5.409 | 51.4 | 4.511 | 50.7 | 5.117 |
| T3 | 54.8 | 1.791 | 54.4 | 3.103 | 54.6 | 2.377 |
| T4 | 38.2 | 18.438 | 60.2 | 4.047 | 46.4 | 18.208 |
| T5 | 55.7 | 3.588 | 56.2 | 2.963 | 55.9 | 3.376 |
| T6 | 33.4 | 20.574 | 59.4 | 3.242 | 43.1 | 20.648 |
| T7 | 55.2 | 3.242 | 55.6 | 3.013 | 55.4 | 3.164 |
| T8 | 55.7 | 2.782 | 54.0 | 7.041 | 55.0 | 4.908 |
| T9 | 55.8 | 2.571 | 57.8 | 1.642 | 56.6 | 2.452 |

AVERAGE DAILY METHANE PRODUCTION PER REACTOR @ STP

| SAMPLE | 28/6-4/7 CH4 AVERAGE (L/day) | 5/7-11/7 CH4 AVERAGE (L/day) | 12/7-18/7 CH4 AVERAGE (L/day) | 19/7-25/7 CH4 AVERAGE (L/day) | 26/7-1/8 CH4 AVERAGE (L/day) | 2/8-8/8 CH4 AVERAGE (L/day) | 9/8-15/8 CH4 AVERAGE (L/day) | 16/8-22/8 CH4 AVERAGE (L/day) | 23/8-25/8 CH4 AVERAGE (L/day) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.886 | 0.966 | 0.752 | 0.617 | 1.010 | 0.928 | 0.825 | 1.261 | 1.040 |
| M1 | 0.731 | 0.952 | 0.733 | 0.378 | 0.882 | 0.863 | 0.777 | 0.763 | 0.738 |
| M2 | 0.915 | 1.159 | 0.401 | 0.385 | 0.147 | 0.043 | 0.000 | 0.195 | 0.082 |
| M3 | 0.675 | 0.639 | 0.619 | 0.636 | 0.841 | 0.763 | 0.589 | 0.637 | 0.647 |
| M4 | 0.686 | 0.571 | 0.705 | 0.631 | 0.372 | 0.125 | 0.043 | 0.078 | 0.046 |
| M5 | 0.790 | 0.893 | 0.978 | 0.817 | 1.116 | 0.836 | 0.537 | 0.793 | 0.741 |
| M6 | 0.751 | 0.661 | 0.686 | 0.626 | 0.791 | 0.953 | 0.754 | 0.872 | 0.600 |
| M7 | 0.813 | 0.960 | 1.153 | 1.442 | 1.460 | 1.388 | 1.358 | 1.424 | 1.269 |
| M8 | 0.847 | 0.879 | 0.942 | 0.889 | 0.942 | 0.692 | 0.568 | 0.840 | 0.736 |
| M9 | 0.813 | 1.016 | 0.880 | 1.011 | 0.836 | 0.667 | 0.485 | 1.179 | 0.945 |
| | | | | | | | | | |
| T0 | 1.350 | 1.207 | 1.088 | 1.289 | 1.730 | 1.558 | 0.887 | 0.845 | 0.672 |
| T1 | 1.003 | 1.351 | 1.222 | 0.648 | 1.340 | 1.195 | 1.154 | 1.155 | 1.033 |
| T2 | 0.717 | 0.637 | 0.156 | 0.135 | 0.267 | 0.042 | 0.034 | 0.010 | 0.024 |
| T3 | 0.706 | 0.738 | 0.543 | 0.444 | 0.567 | 0.451 | 0.379 | 0.697 | 0.517 |
| T4 | 0.981 | 0.820 | 0.518 | 0.034 | 0.230 | 0.985 | 0.597 | 0.987 | 0.994 |
| T5 | 1.213 | 1.540 | 1.343 | 1.296 | 1.775 | 1.817 | 1.631 | 1.751 | 1.429 |
| T6 | 1.145 | 0.521 | 0.559 | 0.029 | 0.139 | 1.281 | 1.022 | 1.409 | 1.221 |
| T7 | 1.010 | 0.724 | 0.691 | 0.684 | 0.999 | 0.795 | 0.720 | 0.934 | 1.017 |
| T8 | 0.904 | 0.800 | 0.650 | 0.555 | 0.679 | 0.659 | 0.431 | 1.245 | 1.326 |
| T9 | 0.937 | 1.249 | 0.947 | 0.954 | 0.973 | 0.857 | 1.028 | 0.892 | 1.012 |

| SAMPLE | JULY CH4 AVERAGE (L/day) | JULY CH4 Std. Dev. (L/day) | AUGUST CH4 AVERAGE (L/day) | AUGUST CH4 Std. Dev. (L/day) | JUL-AUG CH4 AVERAGE (L/day) | JUL-AUG CH4 Std. Dev. (L/day) |
|---|---|---|---|---|---|---|
| M0 | 0.846 | 0.145 | 1.014 | 0.162 | 0.921 | 0.174 |
| M1 | 0.735 | 0.198 | 0.785 | 0.047 | 0.757 | 0.153 |
| M2 | 0.581 | 0.360 | 0.080 | 0.073 | 0.359 | 0.369 |
| M3 | 0.682 | 0.082 | 0.659 | 0.064 | 0.672 | 0.075 |
| M4 | 0.593 | 0.120 | 0.073 | 0.033 | 0.362 | 0.274 |
| M5 | 0.919 | 0.118 | 0.727 | 0.114 | 0.833 | 0.151 |
| M6 | 0.703 | 0.060 | 0.795 | 0.133 | 0.744 | 0.109 |
| M7 | 1.166 | 0.257 | 1.360 | 0.058 | 1.252 | 0.218 |
| M8 | 0.900 | 0.037 | 0.709 | 0.098 | 0.815 | 0.118 |
| M9 | 0.911 | 0.086 | 0.819 | 0.265 | 0.870 | 0.193 |
| | | | | | | |
| T0 | 1.335 | 0.217 | 0.991 | 0.338 | 1.182 | 0.326 |
| T1 | 1.113 | 0.264 | 1.134 | 0.061 | 1.123 | 0.201 |
| T2 | 0.382 | 0.246 | 0.028 | 0.012 | 0.225 | 0.255 |
| T3 | 0.600 | 0.108 | 0.511 | 0.118 | 0.560 | 0.121 |
| T4 | 0.516 | 0.353 | 0.891 | 0.170 | 0.683 | 0.341 |
| T5 | 1.433 | 0.202 | 1.657 | 0.148 | 1.533 | 0.211 |
| T6 | 0.479 | 0.392 | 1.233 | 0.140 | 0.814 | 0.485 |
| T7 | 0.821 | 0.150 | 0.866 | 0.116 | 0.841 | 0.138 |
| T8 | 0.718 | 0.122 | 0.915 | 0.380 | 0.805 | 0.287 |
| T9 | 1.012 | 0.119 | 0.947 | 0.074 | 0.983 | 0.106 |

AVERAGE DAILY BIOGAS PRODUCTION PER UNIT MASS @ STP

| SAMPLE | 28/6-4/7 AVERAGE (L/kg*day) | 5/7-11/7 AVERAGE (L/kg*day) | 12/7-18/7 AVERAGE (L/kg*day) | 19/7-25/7 AVERAGE (L/kg*day) | 26/7-1/8 AVERAGE (L/kg*day) | 2/8-8/8 AVERAGE (L/kg*day) | 9/8-15/8 AVERAGE (L/kg*day) | 16/8-22/8 AVERAGE (L/kg*day) | 23/8-25/8 AVERAGE (L/kg*day) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 1.930 | 2.030 | 1.603 | 1.339 | 2.110 | 1.831 | 1.887 | 2.663 | 2.198 |
| M1 | 2.770 | 3.594 | 2.808 | 1.417 | 3.004 | 2.915 | 2.889 | 2.738 | 2.650 |
| M2 | 3.027 | 4.172 | 1.452 | 1.419 | 0.596 | 0.144 | 0.000 | 0.673 | 0.283 |
| M3 | 3.253 | 3.023 | 3.024 | 2.990 | 3.810 | 3.383 | 2.905 | 3.024 | 3.070 |
| M4 | 3.343 | 2.814 | 3.751 | 3.202 | 1.877 | 0.584 | 0.221 | 0.371 | 0.221 |
| M5 | 3.198 | 3.376 | 3.636 | 3.030 | 3.827 | 2.911 | 2.132 | 3.075 | 2.870 |
| M6 | 2.937 | 2.550 | 2.653 | 2.473 | 2.795 | 3.529 | 3.272 | 3.104 | 2.134 |
| M7 | 3.115 | 3.627 | 4.245 | 5.362 | 4.942 | 4.771 | 5.205 | 5.060 | 4.508 |
| M8 | 3.209 | 3.283 | 3.503 | 3.268 | 3.047 | 2.370 | 2.237 | 3.135 | 2.748 |
| M9 | 2.543 | 3.142 | 2.763 | 3.162 | 2.358 | 1.903 | 1.603 | 3.037 | 2.433 |
| T0 | 2.782 | 2.408 | 2.186 | 2.619 | 3.241 | 2.862 | 1.846 | 1.806 | 1.436 |
| T1 | 3.932 | 5.060 | 4.587 | 2.431 | 4.560 | 4.031 | 4.431 | 4.199 | 3.757 |
| T2 | 3.437 | 3.069 | 0.838 | 0.788 | 1.139 | 0.184 | 0.184 | 0.050 | 0.117 |
| T3 | 3.277 | 3.390 | 2.546 | 2.054 | 2.431 | 1.939 | 1.873 | 3.204 | 2.377 |
| T4 | 3.727 | 3.050 | 1.976 | 0.676 | 2.065 | 3.007 | 2.014 | 3.545 | 3.570 |
| T5 | 4.519 | 5.693 | 5.000 | 4.772 | 5.644 | 6.046 | 6.167 | 6.287 | 5.130 |
| T6 | 4.357 | 2.083 | 2.335 | 0.824 | 2.934 | 4.133 | 3.334 | 5.144 | 4.457 |
| T7 | 3.834 | 2.839 | 2.508 | 2.387 | 3.323 | 2.662 | 2.743 | 3.416 | 3.719 |
| T8 | 3.404 | 2.929 | 2.377 | 2.024 | 2.221 | 2.169 | 1.945 | 4.377 | 4.661 |
| T9 | 2.830 | 3.798 | 2.895 | 2.957 | 2.662 | 2.380 | 3.055 | 2.600 | 2.948 |

| SAMPLE | JULY AVERAGE (L/kg*day) | JULY Std. Dev. (L/kg*day) | AUGUST AVERAGE (L/kg*day) | AUGUST Std. Dev. (L/kg*day) | JUL-AUG AVERAGE (L/kg*day) | JUL-AUG Std. Dev. (L/kg*day) |
|---|---|---|---|---|---|---|
| M0 | 1.802 | 0.289 | 2.145 | 0.330 | 1.955 | 0.352 |
| M1 | 2.719 | 0.714 | 2.798 | 0.109 | 2.754 | 0.539 |
| M2 | 2.133 | 1.288 | 0.275 | 0.251 | 1.307 | 1.342 |
| M3 | 3.220 | 0.310 | 3.095 | 0.177 | 3.165 | 0.266 |
| M4 | 2.997 | 0.635 | 0.349 | 0.149 | 1.820 | 1.402 |
| M5 | 3.413 | 0.288 | 2.747 | 0.363 | 3.117 | 0.463 |
| M6 | 2.682 | 0.167 | 3.010 | 0.528 | 2.827 | 0.407 |
| M7 | 4.258 | 0.824 | 4.886 | 0.268 | 4.537 | 0.711 |
| M8 | 3.262 | 0.147 | 2.623 | 0.350 | 2.978 | 0.409 |
| M9 | 2.794 | 0.319 | 2.244 | 0.546 | 2.549 | 0.513 |
| T0 | 2.647 | 0.358 | 1.987 | 0.530 | 2.354 | 0.551 |
| T1 | 4.114 | 0.914 | 4.104 | 0.246 | 4.110 | 0.701 |
| T2 | 1.854 | 1.154 | 0.134 | 0.056 | 1.090 | 1.213 |
| T3 | 2.740 | 0.513 | 2.348 | 0.531 | 2.566 | 0.556 |
| T4 | 2.299 | 1.039 | 3.034 | 0.630 | 2.626 | 0.954 |
| T5 | 5.126 | 0.469 | 5.907 | 0.457 | 5.473 | 0.605 |
| T6 | 2.507 | 1.153 | 4.267 | 0.651 | 3.289 | 1.301 |
| T7 | 2.978 | 0.537 | 3.135 | 0.446 | 3.048 | 0.505 |
| T8 | 2.591 | 0.506 | 3.288 | 1.238 | 2.901 | 0.971 |
| T9 | 3.028 | 0.397 | 2.746 | 0.270 | 2.903 | 0.374 |

AVERAGE DAILY METHANE PRODUCTION PER UNIT MASS @ STP

| SAMPLE | 28/6-4/7 CH4 AVERAGE (L/kg*day) | 5/7-11/7 CH4 AVERAGE (L/kg*day) | 12/7-18/7 CH4 AVERAGE (L/kg*day) | 19/7-25/7 CH4 AVERAGE (L/kg*day) | 26/7-1/8 CH4 AVERAGE (L/kg*day) | 2/8-8/8 CH4 AVERAGE (L/kg*day) | 9/8-15/8 CH4 AVERAGE (L/kg*day) | 16/8-22/8 CH4 AVERAGE (L/kg*day) | 23/8-25/8 CH4 AVERAGE (L/kg*day) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.984 | 1.074 | 0.835 | 0.686 | 1.123 | 1.031 | 0.917 | 1.401 | 1.156 |
| M1 | 1.462 | 1.905 | 1.466 | 0.755 | 1.764 | 1.725 | 1.554 | 1.525 | 1.476 |
| M2 | 1.630 | 2.318 | 0.803 | 0.771 | 0.293 | 0.086 | 0.000 | 0.391 | 0.164 |
| M3 | 1.688 | 1.598 | 1.548 | 1.591 | 2.103 | 1.908 | 1.473 | 1.594 | 1.618 |
| M4 | 1.715 | 1.428 | 1.763 | 1.578 | 0.931 | 0.312 | 0.107 | 0.194 | 0.116 |
| M5 | 1.580 | 1.785 | 1.956 | 1.633 | 2.231 | 1.671 | 1.075 | 1.587 | 1.481 |
| M6 | 1.502 | 1.322 | 1.372 | 1.251 | 1.582 | 1.906 | 1.508 | 1.744 | 1.199 |
| M7 | 1.627 | 1.920 | 2.305 | 2.885 | 2.921 | 2.777 | 2.717 | 2.849 | 2.538 |
| M8 | 1.695 | 1.759 | 1.885 | 1.778 | 1.883 | 1.384 | 1.137 | 1.681 | 1.473 |
| M9 | 1.356 | 1.693 | 1.467 | 1.685 | 1.394 | 1.112 | 0.808 | 1.965 | 1.574 |
| T0 | 1.511 | 1.341 | 1.209 | 1.433 | 1.922 | 1.732 | 0.986 | 0.939 | 0.746 |
| T1 | 2.007 | 2.703 | 2.445 | 1.296 | 2.681 | 2.391 | 2.308 | 2.309 | 2.066 |
| T2 | 1.793 | 1.593 | 0.389 | 0.336 | 0.667 | 0.105 | 0.085 | 0.026 | 0.060 |
| T3 | 1.765 | 1.845 | 1.357 | 1.111 | 1.418 | 1.128 | 0.948 | 1.743 | 1.293 |
| T4 | 1.962 | 1.640 | 1.035 | 0.068 | 0.461 | 1.970 | 1.194 | 1.974 | 1.988 |
| T5 | 2.426 | 3.081 | 2.685 | 2.591 | 3.550 | 3.634 | 3.262 | 3.502 | 2.857 |
| T6 | 2.291 | 1.042 | 1.118 | 0.059 | 0.279 | 2.562 | 2.043 | 2.819 | 2.442 |
| T7 | 2.020 | 1.448 | 1.382 | 1.368 | 1.997 | 1.589 | 1.440 | 1.869 | 2.034 |
| T8 | 1.808 | 1.601 | 1.300 | 1.109 | 1.357 | 1.318 | 0.862 | 2.490 | 2.652 |
| T9 | 1.562 | 2.081 | 1.578 | 1.591 | 1.621 | 1.428 | 1.714 | 1.487 | 1.686 |

| SAMPLE | JULY CH4 AVERAGE (L/kg*day) | JULY CH4 Std. Dev. (L/kg*day) | AUGUST CH4 AVERAGE (L/kg*day) | AUGUST CH4 Std. Dev. (L/kg*day) | JUL-AUG CH4 AVERAGE (L/kg*day) | JUL-AUG CH4 Std. Dev. (L/kg*day) |
|---|---|---|---|---|---|---|
| M0 | 0.940 | 0.161 | 1.126 | 0.180 | 1.023 | 0.193 |
| M1 | 1.470 | 0.397 | 1.570 | 0.094 | 1.515 | 0.306 |
| M2 | 1.163 | 0.720 | 0.160 | 0.145 | 0.717 | 0.739 |
| M3 | 1.706 | 0.204 | 1.648 | 0.160 | 1.680 | 0.188 |
| M4 | 1.483 | 0.300 | 0.182 | 0.082 | 0.905 | 0.686 |
| M5 | 1.837 | 0.237 | 1.453 | 0.229 | 1.667 | 0.301 |
| M6 | 1.406 | 0.120 | 1.589 | 0.266 | 1.487 | 0.219 |
| M7 | 2.332 | 0.514 | 2.720 | 0.115 | 2.504 | 0.436 |
| M8 | 1.800 | 0.074 | 1.418 | 0.195 | 1.630 | 0.236 |
| M9 | 1.519 | 0.144 | 1.365 | 0.441 | 1.450 | 0.322 |
| T0 | 1.483 | 0.241 | 1.101 | 0.375 | 1.313 | 0.362 |
| T1 | 2.226 | 0.528 | 2.269 | 0.122 | 2.245 | 0.403 |
| T2 | 0.956 | 0.616 | 0.069 | 0.030 | 0.562 | 0.637 |
| T3 | 1.499 | 0.271 | 1.278 | 0.295 | 1.401 | 0.303 |
| T4 | 1.033 | 0.706 | 1.782 | 0.339 | 1.366 | 0.683 |
| T5 | 2.867 | 0.404 | 3.314 | 0.295 | 3.065 | 0.423 |
| T6 | 0.958 | 0.785 | 2.467 | 0.280 | 1.628 | 0.969 |
| T7 | 1.643 | 0.300 | 1.733 | 0.232 | 1.683 | 0.276 |
| T8 | 1.435 | 0.244 | 1.831 | 0.760 | 1.611 | 0.573 |
| T9 | 1.687 | 0.198 | 1.579 | 0.123 | 1.639 | 0.177 |

AVERAGE DAILY BIOGAS PRODUCTION PER UNIT MASS as TS @ STP

| SAMPLE | 28/6-4/7 | 5/7-11/7 | 12/7-18/7 | 19/7-25/7 | 26/7-1/8 | 2/8-8/8 | 9/8-15/8 | 16/8-22/8 | 23/8-25/8 |
|---|---|---|---|---|---|---|---|---|---|
| | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) |
| M0 | 7.005 | 7.368 | 5.820 | 4.860 | 7.659 | 6.647 | 6.848 | 9.667 | 7.977 |
| M1 | 11.102 | 14.403 | 11.254 | 5.679 | 12.042 | 11.682 | 11.580 | 10.974 | 10.620 |
| M2 | 12.836 | 17.691 | 6.155 | 6.018 | 2.528 | 0.609 | 0.000 | 2.855 | 1.201 |
| M3 | 8.321 | 7.732 | 7.736 | 7.649 | 9.747 | 8.654 | 7.430 | 7.736 | 7.853 |
| M4 | 9.024 | 7.596 | 10.124 | 8.641 | 5.066 | 1.576 | 0.596 | 1.000 | 0.596 |
| M5 | 11.310 | 11.938 | 12.857 | 10.714 | 13.533 | 10.295 | 7.540 | 10.875 | 10.150 |
| M6 | 8.660 | 7.521 | 7.824 | 7.293 | 8.242 | 10.407 | 9.648 | 9.154 | 6.292 |
| M7 | 9.542 | 11.112 | 13.004 | 16.426 | 15.138 | 14.614 | 15.943 | 15.500 | 13.809 |
| M8 | 11.273 | 11.532 | 12.308 | 11.480 | 10.705 | 8.326 | 7.860 | 11.015 | 9.653 |
| M9 | 13.507 | 16.684 | 14.675 | 16.791 | 12.524 | 10.108 | 8.515 | 16.127 | 12.923 |
| T0 | 10.136 | 8.772 | 7.962 | 9.541 | 11.807 | 10.427 | 6.723 | 6.578 | 5.230 |
| T1 | 13.719 | 17.655 | 16.004 | 8.484 | 15.909 | 14.066 | 15.460 | 14.651 | 13.108 |
| T2 | 9.121 | 8.145 | 2.223 | 2.090 | 3.024 | 0.489 | 0.489 | 0.133 | 0.311 |
| T3 | 8.911 | 9.218 | 6.924 | 5.584 | 6.612 | 5.271 | 5.093 | 8.711 | 6.463 |
| T4 | 13.463 | 11.018 | 7.137 | 2.441 | 7.460 | 10.863 | 7.275 | 12.803 | 12.894 |
| T5 | 14.286 | 17.999 | 15.809 | 15.088 | 17.843 | 19.115 | 19.496 | 19.878 | 16.219 |
| T6 | 13.735 | 6.567 | 7.361 | 2.598 | 9.251 | 13.029 | 10.509 | 16.217 | 14.051 |
| T7 | 15.038 | 11.137 | 9.837 | 9.362 | 13.035 | 10.443 | 10.758 | 13.399 | 14.586 |
| T8 | 14.641 | 12.596 | 10.222 | 8.705 | 9.553 | 9.327 | 8.366 | 18.824 | 20.049 |
| T9 | 14.533 | 19.540 | 14.969 | 15.288 | 13.762 | 12.306 | 15.796 | 13.444 | 15.245 |

| SAMPLE | JULY | JULY | AUGUST | AUGUST | JUL-AUG | JUL-AUG |
|---|---|---|---|---|---|---|
| | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) | AVERAGE (L/kgTS*d) |
| M0 | 6.542 | 1.048 | 7.785 | 1.199 | 7.095 | 1.277 |
| M1 | 10.896 | 2.864 | 11.214 | 0.437 | 11.037 | 2.160 |
| M2 | 9.046 | 5.461 | 1.166 | 1.064 | 5.544 | 5.692 |
| M3 | 8.237 | 0.792 | 7.919 | 0.452 | 8.096 | 0.682 |
| M4 | 8.090 | 1.715 | 0.942 | 0.401 | 4.913 | 3.784 |
| M5 | 12.070 | 1.019 | 9.715 | 1.285 | 11.024 | 1.637 |
| M6 | 7.908 | 0.493 | 8.875 | 1.557 | 8.338 | 1.201 |
| M7 | 13.044 | 2.523 | 14.967 | 0.822 | 13.899 | 2.179 |
| M8 | 11.460 | 0.516 | 9.213 | 1.231 | 10.461 | 1.437 |
| M9 | 14.836 | 1.695 | 11.918 | 2.897 | 13.539 | 2.726 |
| T0 | 9.643 | 1.306 | 7.239 | 1.930 | 8.575 | 2.007 |
| T1 | 14.354 | 3.191 | 14.321 | 0.858 | 14.340 | 2.446 |
| T2 | 4.921 | 3.063 | 0.356 | 0.147 | 2.892 | 3.220 |
| T3 | 7.450 | 1.394 | 6.385 | 1.443 | 6.976 | 1.512 |
| T4 | 8.304 | 3.753 | 10.959 | 2.276 | 9.484 | 3.445 |
| T5 | 16.205 | 1.482 | 18.677 | 1.445 | 17.304 | 1.912 |
| T6 | 7.902 | 3.635 | 13.452 | 2.052 | 10.369 | 4.101 |
| T7 | 11.682 | 2.106 | 12.296 | 1.751 | 11.955 | 1.980 |
| T8 | 11.144 | 2.176 | 14.142 | 5.323 | 12.476 | 4.177 |
| T9 | 15.658 | 2.055 | 14.198 | 1.396 | 15.009 | 1.934 |

AVERAGE DAILY METHANE PRODUCTION PER UNIT MASS as TS @ STP

| SAMPLE | 28/6-4/7 CH4 AVERAGE (L/kgTS*d) | 5/7-11/7 CH4 AVERAGE (L/kgTS*d) | 12/7-18/7 CH4 AVERAGE (L/kgTS*d) | 19/7-25/7 CH4 AVERAGE (L/kgTS*d) | 26/7-1/8 CH4 AVERAGE (L/kgTS*d) | 2/8-8/8 CH4 AVERAGE (L/kgTS*d) | 9/8-15/8 CH4 AVERAGE (L/kgTS*d) | 16/8-22/8 CH4 AVERAGE (L/kgTS*d) | 23/8-25/8 CH4 AVERAGE (L/kgTS*d) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 3.573 | 3.898 | 3.032 | 2.488 | 4.074 | 3.742 | 3.328 | 5.085 | 4.196 |
| M1 | 5.863 | 7.635 | 5.875 | 3.027 | 7.069 | 6.916 | 6.230 | 6.112 | 5.915 |
| M2 | 6.912 | 9.828 | 3.404 | 3.268 | 1.244 | 0.366 | 0.000 | 1.656 | 0.697 |
| M3 | 4.319 | 4.087 | 3.961 | 4.069 | 5.380 | 4.881 | 3.767 | 4.077 | 4.139 |
| M4 | 4.628 | 3.855 | 4.758 | 4.260 | 2.513 | 0.843 | 0.288 | 0.524 | 0.312 |
| M5 | 5.588 | 6.312 | 6.917 | 5.775 | 7.890 | 5.909 | 3.800 | 5.611 | 5.237 |
| M6 | 4.428 | 3.900 | 4.045 | 3.690 | 4.565 | 5.620 | 4.448 | 5.144 | 3.536 |
| M7 | 4.983 | 5.883 | 7.061 | 8.837 | 8.946 | 8.506 | 8.322 | 8.727 | 7.775 |
| M8 | 5.953 | 6.178 | 6.621 | 5.245 | 6.515 | 4.362 | 3.993 | 5.904 | 5.174 |
| M9 | 7.199 | 8.993 | 7.793 | 8.949 | 7.402 | 5.903 | 4.291 | 10.434 | 8.361 |
| T0 | 5.504 | 4.886 | 4.403 | 5.219 | 7.002 | 6.308 | 3.590 | 3.420 | 2.719 |
| T1 | 7.002 | 9.430 | 8.530 | 4.522 | 9.354 | 6.341 | 8.054 | 8.058 | 7.209 |
| T2 | 4.759 | 4.227 | 1.032 | 0.892 | 1.769 | 0.280 | 0.226 | 0.068 | 0.158 |
| T3 | 4.798 | 5.017 | 3.691 | 3.021 | 3.855 | 3.068 | 2.577 | 4.739 | 3.516 |
| T4 | 7.086 | 5.922 | 3.740 | 0.244 | 1.664 | 7.115 | 4.314 | 7.132 | 7.182 |
| T5 | 7.669 | 9.740 | 8.489 | 8.193 | 11.223 | 11.488 | 10.313 | 11.072 | 9.034 |
| T6 | 7.222 | 3.284 | 3.526 | 0.184 | 0.879 | 8.078 | 6.442 | 8.887 | 7.700 |
| T7 | 7.923 | 5.678 | 5.420 | 5.364 | 7.834 | 6.234 | 5.648 | 7.329 | 7.978 |
| T8 | 7.779 | 5.884 | 5.592 | 4.771 | 5.837 | 5.671 | 3.706 | 10.711 | 11.408 |
| T9 | 8.077 | 10.763 | 8.158 | 8.225 | 8.381 | 7.384 | 8.862 | 7.690 | 8.720 |

| SAMPLE | JULY CH4 AVERAGE (L/kgTS*d) | JULY CH4 Std. Dev. (L/kgTS*d) | AUGUST CH4 AVERAGE (L/kgTS*d) | AUGUST CH4 Std. Dev. (L/kgTS*d) | JUL-AUG CH4 AVERAGE (L/kgTS*d) | JUL-AUG CH4 Std. Dev. (L/kgTS*d) |
|---|---|---|---|---|---|---|
| M0 | 3.413 | 0.583 | 4.088 | 0.652 | 3.713 | 0.700 |
| M1 | 5.894 | 1.590 | 6.293 | 0.376 | 6.071 | 1.227 |
| M2 | 4.931 | 3.053 | 0.680 | 0.615 | 3.042 | 3.132 |
| M3 | 4.363 | 0.522 | 4.216 | 0.409 | 4.298 | 0.481 |
| M4 | 4.003 | 0.809 | 0.492 | 0.223 | 2.442 | 1.852 |
| M5 | 6.496 | 0.836 | 5.140 | 0.809 | 5.893 | 1.065 |
| M6 | 4.146 | 0.354 | 4.687 | 0.784 | 4.386 | 0.645 |
| M7 | 7.142 | 1.574 | 8.332 | 0.352 | 7.671 | 1.335 |
| M8 | 6.323 | 0.260 | 4.983 | 0.685 | 5.727 | 0.830 |
| M9 | 8.067 | 0.762 | 7.247 | 2.342 | 7.703 | 1.711 |
| T0 | 5.403 | 0.880 | 4.010 | 1.367 | 4.783 | 1.319 |
| T1 | 7.768 | 1.843 | 7.916 | 0.424 | 7.833 | 1.404 |
| T2 | 2.536 | 1.634 | 0.183 | 0.079 | 1.490 | 1.689 |
| T3 | 4.076 | 0.737 | 3.475 | 0.802 | 3.809 | 0.823 |
| T4 | 3.731 | 2.549 | 6.436 | 1.225 | 4.933 | 2.466 |
| T5 | 9.063 | 1.277 | 10.477 | 0.933 | 9.691 | 1.337 |
| T6 | 3.019 | 2.474 | 7.777 | 0.882 | 5.134 | 3.055 |
| T7 | 6.444 | 1.177 | 6.797 | 0.911 | 6.601 | 1.081 |
| T8 | 6.172 | 1.049 | 7.874 | 3.270 | 6.929 | 2.465 |
| T9 | 8.721 | 1.026 | 8.164 | 0.638 | 8.473 | 0.918 |

AVERAGE DAILY BIOGAS PRODUCTION PER UNIT VOLUME @ STP

| SAMPLE | 28/6-4/7 | 5/7-11/7 | 12/7-18/7 | 19/7-25/7 | 26/7-1/8 | 2/8-8/8 | 9/8-15/8 | 16/8-22/8 | 23/8-25/8 |
|---|---|---|---|---|---|---|---|---|---|
| | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) | AVERAGE (L/L*day) |
| M0 | 0.826 | 0.869 | 0.686 | 0.573 | 0.903 | 0.784 | 0.807 | 1.140 | 0.941 |
| M1 | 1.291 | 1.675 | 1.308 | 0.660 | 1.400 | 1.358 | 1.346 | 1.276 | 1.235 |
| M2 | 1.473 | 2.030 | 0.706 | 0.691 | 0.290 | 0.070 | 0.000 | 0.328 | 0.138 |
| M3 | 0.836 | 0.777 | 0.777 | 0.768 | 0.979 | 0.869 | 0.746 | 0.777 | 0.789 |
| M4 | 0.960 | 0.808 | 1.077 | 0.919 | 0.539 | 0.168 | 0.063 | 0.106 | 0.063 |
| M5 | 1.334 | 1.408 | 1.516 | 1.263 | 1.596 | 1.214 | 0.889 | 1.282 | 1.197 |
| M6 | 0.981 | 0.852 | 0.886 | 0.826 | 0.933 | 1.178 | 1.092 | 1.036 | 0.712 |
| M7 | 1.098 | 1.279 | 1.497 | 1.891 | 1.742 | 1.682 | 1.835 | 1.784 | 1.590 |
| M8 | 1.329 | 1.359 | 1.450 | 1.353 | 1.261 | 0.981 | 0.926 | 1.298 | 1.138 |
| M9 | 1.417 | 1.750 | 1.539 | 1.761 | 1.314 | 1.060 | 0.893 | 1.691 | 1.355 |
| T0 | 1.194 | 1.033 | 0.938 | 1.124 | 1.390 | 1.228 | 0.792 | 0.775 | 0.616 |
| T1 | 1.618 | 2.082 | 1.887 | 1.001 | 1.876 | 1.659 | 1.823 | 1.728 | 1.546 |
| T2 | 0.956 | 0.853 | 0.233 | 0.219 | 0.317 | 0.051 | 0.051 | 0.014 | 0.033 |
| T3 | 0.954 | 0.986 | 0.741 | 0.598 | 0.708 | 0.564 | 0.545 | 0.932 | 0.692 |
| T4 | 1.588 | 1.299 | 0.842 | 0.288 | 0.880 | 1.281 | 0.858 | 1.510 | 1.521 |
| T5 | 1.663 | 2.095 | 1.840 | 1.756 | 2.077 | 2.225 | 2.269 | 2.314 | 1.888 |
| T6 | 1.596 | 0.753 | 0.855 | 0.302 | 1.075 | 1.514 | 1.221 | 1.884 | 1.633 |
| T7 | 1.757 | 1.302 | 1.150 | 1.094 | 1.523 | 1.220 | 1.257 | 1.566 | 1.705 |
| T8 | 1.673 | 1.440 | 1.168 | 0.995 | 1.092 | 1.066 | 0.956 | 2.152 | 2.292 |
| T9 | 1.554 | 2.085 | 1.589 | 1.623 | 1.461 | 1.307 | 1.677 | 1.427 | 1.619 |

| SAMPLE | JULY | JULY | AUGUST | AUGUST | JUL-AUG | JUL-AUG |
|---|---|---|---|---|---|---|
| | AVERAGE (L/L*day) | Std. Dev. (L/L*day) | AVERAGE (L/L*day) | Std. Dev. (L/L*day) | AVERAGE (L/L*day) | Std. Dev. (L/L*day) |
| M0 | 0.771 | 0.124 | 0.918 | 0.141 | 0.837 | 0.151 |
| M1 | 1.267 | 0.333 | 1.304 | 0.051 | 1.283 | 0.251 |
| M2 | 1.038 | 0.627 | 0.134 | 0.122 | 0.636 | 0.653 |
| M3 | 0.828 | 0.080 | 0.796 | 0.045 | 0.813 | 0.068 |
| M4 | 0.860 | 0.182 | 0.100 | 0.043 | 0.522 | 0.402 |
| M5 | 1.423 | 0.120 | 1.146 | 0.152 | 1.300 | 0.193 |
| M6 | 0.895 | 0.056 | 1.005 | 0.176 | 0.944 | 0.136 |
| M7 | 1.501 | 0.290 | 1.723 | 0.095 | 1.600 | 0.251 |
| M8 | 1.350 | 0.061 | 1.086 | 0.145 | 1.233 | 0.169 |
| M9 | 1.556 | 0.178 | 1.250 | 0.304 | 1.420 | 0.286 |
| T0 | 1.136 | 0.154 | 0.853 | 0.227 | 1.010 | 0.236 |
| T1 | 1.693 | 0.376 | 1.689 | 0.101 | 1.691 | 0.288 |
| T2 | 0.515 | 0.321 | 0.037 | 0.015 | 0.303 | 0.337 |
| T3 | 0.797 | 0.149 | 0.683 | 0.154 | 0.747 | 0.162 |
| T4 | 0.979 | 0.443 | 1.292 | 0.268 | 1.118 | 0.406 |
| T5 | 1.886 | 0.173 | 2.174 | 0.168 | 2.014 | 0.223 |
| T6 | 0.918 | 0.422 | 1.563 | 0.238 | 1.205 | 0.476 |
| T7 | 1.365 | 0.246 | 1.437 | 0.205 | 1.397 | 0.231 |
| T8 | 1.274 | 0.249 | 1.616 | 0.608 | 1.426 | 0.477 |
| T9 | 1.663 | 0.218 | 1.507 | 0.148 | 1.594 | 0.205 |

AVERAGE DAILY METHANE PRODUCTION PER UNIT VOLUME @ STP

| SAMPLE | 28/6-4/7 CH4 AVERAGE (L/L*day) | 5/7-11/7 CH4 AVERAGE (L/L*day) | 12/7-18/7 CH4 AVERAGE (L/L*day) | 19/7-25/7 CH4 AVERAGE (L/L*day) | 26/7-1/8 CH4 AVERAGE (L/L*day) | 2/8-8/8 CH4 AVERAGE (L/L*day) | 9/8-15/8 CH4 AVERAGE (L/L*day) | 16/8-22/8 CH4 AVERAGE (L/L*day) | 23/8-25/8 CH4 AVERAGE (L/L*day) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.421 | 0.460 | 0.358 | 0.293 | 0.480 | 0.441 | 0.392 | 0.600 | 0.495 |
| M1 | 0.682 | 0.888 | 0.683 | 0.352 | 0.822 | 0.804 | 0.724 | 0.711 | 0.688 |
| M2 | 0.793 | 1.128 | 0.391 | 0.375 | 0.143 | 0.042 | 0.000 | 0.190 | 0.080 |
| M3 | 0.434 | 0.411 | 0.398 | 0.409 | 0.541 | 0.490 | 0.378 | 0.410 | 0.416 |
| M4 | 0.492 | 0.410 | 0.506 | 0.453 | 0.267 | 0.090 | 0.031 | 0.056 | 0.033 |
| M5 | 0.659 | 0.744 | 0.816 | 0.681 | 0.930 | 0.697 | 0.448 | 0.662 | 0.618 |
| M6 | 0.501 | 0.442 | 0.458 | 0.418 | 0.528 | 0.636 | 0.504 | 0.582 | 0.400 |
| M7 | 0.574 | 0.677 | 0.813 | 1.017 | 1.030 | 0.979 | 0.958 | 1.004 | 0.895 |
| M8 | 0.702 | 0.728 | 0.780 | 0.736 | 0.730 | 0.573 | 0.471 | 0.696 | 0.610 |
| M9 | 0.755 | 0.943 | 0.817 | 0.939 | 0.776 | 0.619 | 0.450 | 1.094 | 0.877 |
| T0 | 0.648 | 0.575 | 0.518 | 0.615 | 0.825 | 0.743 | 0.423 | 0.403 | 0.320 |
| T1 | 0.826 | 1.112 | 1.006 | 0.533 | 1.103 | 0.984 | 0.950 | 0.950 | 0.850 |
| T2 | 0.499 | 0.443 | 0.108 | 0.093 | 0.185 | 0.029 | 0.024 | 0.007 | 0.017 |
| T3 | 0.514 | 0.537 | 0.395 | 0.323 | 0.412 | 0.328 | 0.276 | 0.507 | 0.376 |
| T4 | 0.836 | 0.698 | 0.441 | 0.029 | 0.196 | 0.839 | 0.509 | 0.841 | 0.847 |
| T5 | 0.893 | 1.134 | 0.988 | 0.954 | 1.306 | 1.337 | 1.200 | 1.289 | 1.052 |
| T6 | 0.839 | 0.382 | 0.410 | 0.021 | 0.102 | 0.939 | 0.749 | 1.033 | 0.895 |
| T7 | 0.926 | 0.664 | 0.633 | 0.627 | 0.916 | 0.729 | 0.660 | 0.857 | 0.932 |
| T8 | 0.889 | 0.787 | 0.639 | 0.545 | 0.667 | 0.648 | 0.424 | 1.224 | 1.304 |
| T9 | 0.858 | 1.143 | 0.866 | 0.873 | 0.890 | 0.784 | 0.941 | 0.816 | 0.926 |

| SAMPLE | JULY CH4 AVERAGE (L/L*day) | JULY CH4 Std. Dev. (L/L*day) | AUGUST CH4 AVERAGE (L/L*day) | AUGUST CH4 Std. Dev. (L/L*day) | JUL-AUG CH4 AVERAGE (L/L*day) | JUL-AUG CH4 Std. Dev. (L/L*day) |
|---|---|---|---|---|---|---|
| M0 | 0.402 | 0.069 | 0.482 | 0.077 | 0.438 | 0.083 |
| M1 | 0.685 | 0.185 | 0.732 | 0.044 | 0.706 | 0.143 |
| M2 | 0.566 | 0.350 | 0.078 | 0.071 | 0.349 | 0.359 |
| M3 | 0.438 | 0.052 | 0.424 | 0.041 | 0.432 | 0.048 |
| M4 | 0.426 | 0.086 | 0.052 | 0.024 | 0.260 | 0.197 |
| M5 | 0.766 | 0.099 | 0.606 | 0.095 | 0.695 | 0.126 |
| M6 | 0.469 | 0.040 | 0.531 | 0.089 | 0.497 | 0.073 |
| M7 | 0.822 | 0.181 | 0.959 | 0.041 | 0.883 | 0.154 |
| M8 | 0.745 | 0.031 | 0.587 | 0.081 | 0.675 | 0.098 |
| M9 | 0.846 | 0.080 | 0.760 | 0.246 | 0.808 | 0.179 |
| T0 | 0.636 | 0.104 | 0.472 | 0.161 | 0.563 | 0.155 |
| T1 | 0.916 | 0.217 | 0.934 | 0.050 | 0.924 | 0.166 |
| T2 | 0.266 | 0.171 | 0.019 | 0.008 | 0.156 | 0.177 |
| T3 | 0.436 | 0.079 | 0.372 | 0.086 | 0.408 | 0.088 |
| T4 | 0.440 | 0.301 | 0.759 | 0.144 | 0.582 | 0.291 |
| T5 | 1.055 | 0.149 | 1.219 | 0.109 | 1.128 | 0.156 |
| T6 | 0.351 | 0.287 | 0.904 | 0.102 | 0.596 | 0.355 |
| T7 | 0.753 | 0.138 | 0.794 | 0.106 | 0.771 | 0.126 |
| T8 | 0.705 | 0.120 | 0.900 | 0.374 | 0.792 | 0.282 |
| T9 | 0.926 | 0.109 | 0.867 | 0.068 | 0.900 | 0.097 |

B3: TOTAL SOLIDS VOLATILE SOLIDS and pH

# Solids and pH Data

Tu 4/7/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 21.11 | 113.12 | 23.88 | 8.85 |
| M1 | 21.95 | 93.31 | 20.48 | 9.20 |
| M2 | 20.02 | 94.54 | 18.92 | 9.10 |
| M3 | 37.50 | 94.22 | 35.33 | 8.00 |
| M4 | 37.74 | 95.81 | 36.16 | 7.40 |
| M5 | 30.10 | 93.95 | 28.27 | 8.50 |
| M6 | 37.12 | 93.53 | 34.72 | 8.20 |
| M7 | 32.97 | 94.46 | 31.14 | 8.35 |
| M8 | 30.18 | 94.83 | 28.62 | 8.75 |
| M9 | 17.05 | 93.62 | 15.97 | 9.30 |
| T0 | 24.58 | 94.59 | 23.26 | 9.10 |
| T1 | 27.10 | 93.21 | 25.26 | 9.20 |
| T2 | 38.27 | 94.97 | 36.34 | 8.15 |
| T3 | 35.59 | 95.36 | 34.04 | 8.75 |
| T4 | 26.68 | 95.69 | 25.53 | 8.60 |
| T5 | 32.09 | 95.33 | 30.59 | 9.00 |
| T6 | 31.69 | 96.03 | 30.43 | 8.55 |
| T7 | 27.09 | 93.31 | 25.28 | 8.80 |
| T8 | 23.60 | 94.64 | 22.34 | 9.00 |
| T9 | 19.65 | 94.62 | 18.59 | 9.20 |
| Fri 7/7/89 | | | | |
| M0 | 25.82 | 95.47 | 24.65 | 8.60 |
| M1 | 22.39 | 93.06 | 20.84 | 9.00 |
| M2 | 21.17 | 94.81 | 20.07 | 8.50 |
| M3 | 38.18 | 94.34 | 36.01 | 7.70 |
| M4 | 38.67 | 95.97 | 37.11 | 7.00 |
| M5 | 28.39 | 94.06 | 26.71 | 8.50 |
| M6 | 35.23 | 94.41 | 33.26 | 7.50 |
| M7 | 32.87 | 94.49 | 31.06 | 8.20 |
| M8 | 30.21 | 94.60 | 28.58 | 8.70 |
| M9 | 17.23 | 93.75 | 16.15 | 9.00 |
| T0 | 24.69 | 94.57 | 23.35 | 9.00 |
| T1 | 27.22 | 93.19 | 25.37 | 9.00 |
| T2 | 37.22 | 94.37 | 35.12 | 8.00 |
| T3 | 36.84 | 96.06 | 35.39 | 8.60 |
| T4 | 27.09 | 95.88 | 25.98 | 8.25 |
| T5 | 32.30 | 93.87 | 30.32 | 8.90 |
| T6 | 32.56 | 96.46 | 31.41 | 8.20 |
| T7 | 26.15 | 93.87 | 24.54 | 8.80 |
| T8 | 23.30 | 94.68 | 22.06 | 8.95 |
| T9 | 19.07 | 94.49 | 18.02 | 9.05 |

Solids and pH Data

Tues 11/7/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 27.60 | 95.59 | 26.38 | 8.50 |
| M1 | 28.67 | 95.35 | 27.33 | 8.80 |
| M2 | 23.58 | 95.33 | 22.48 | 9.00 |
| M3 | 38.25 | 94.78 | 36.25 | 7.70 |
| M4 | 38.99 | 96.44 | 37.61 | 6.00 |
| M5 | 28.09 | 94.20 | 26.46 | 8.50 |
| M6 | 34.26 | 94.26 | 32.29 | 7.60 |
| M7 | 31.51 | 95.09 | 29.96 | 8.50 |
| M8 | 29.78 | 95.27 | 28.37 | 8.60 |
| M9 | 19.23 | 94.19 | 18.11 | 9.00 |
| T0 | 27.83 | 94.64 | 26.34 | 9.00 |
| T1 | 31.06 | 93.23 | 28.96 | 9.20 |
| T2 | 37.63 | 95.05 | 35.76 | 7.50 |
| T3 | 36.27 | 96.19 | 34.89 | 8.80 |
| T4 | 28.83 | 96.07 | 27.69 | 7.90 |
| T5 | 31.48 | 94.22 | 29.66 | 8.90 |
| T6 | 33.55 | 96.46 | 32.36 | 7.50 |
| T7 | 25.71 | 94.07 | 24.19 | 9.00 |
| T8 | 24.13 | 95.06 | 22.93 | 9.00 |
| T9 | 18.44 | 94.70 | 17.46 | 9.00 |

Fri 14/7/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 27.51 | 95.44 | 26.25 | 7.30 |
| M1 | 26.70 | 94.43 | 25.21 | 8.60 |
| M2 | 22.83 | 95.65 | 21.84 | 8.50 |
| M3 | 38.18 | 93.93 | 35.86 | 7.50 |
| M4 | 37.92 | 96.08 | 36.43 | 6.05 |
| M5 | 27.43 | 93.91 | 25.76 | 8.60 |
| M6 | 33.83 | 94.53 | 31.98 | 7.40 |
| M7 | 30.35 | 95.73 | 29.05 | 8.50 |
| M8 | 28.06 | 95.10 | 26.69 | 8.60 |
| M9 | 18.80 | 94.80 | 17.82 | 8.40 |
| T0 | 28.71 | 95.06 | 27.29 | 9.00 |
| T1 | 29.00 | 93.06 | 26.99 | 9.10 |
| T2 | 38.63 | 94.35 | 36.45 | 7.30 |
| T3 | 36.75 | 96.56 | 35.48 | 8.60 |
| T4 | 26.95 | 96.11 | 25.90 | 7.90 |
| T5 | 31.42 | 94.30 | 29.63 | 8.90 |
| T6 | 33.33 | 96.80 | 32.27 | 7.10 |
| T7 | 26.68 | 94.38 | 25.18 | 9.00 |
| T8 | 24.62 | 95.07 | 23.40 | 9.00 |
| T9 | 18.68 | 95.45 | 17.83 | 9.00 |

Solids and pH Data

Tues 18/7/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 27.45 | 96.15 | 26.39 | 6.90 |
| M1 | 25.81 | 93.86 | 24.23 | 8.60 |
| M2 | 23.00 | 95.40 | 21.94 | 8.60 |
| M3 | 39.10 | 93.85 | 36.69 | 7.60 |
| M4 | | | | |
| M5 | 27.71 | 93.65 | 25.95 | 8.50 |
| M6 | 34.85 | 93.68 | 32.64 | 7.50 |
| M7 | 31.61 | 95.04 | 30.04 | 8.50 |
| M8 | 28.25 | 94.89 | 26.81 | 8.70 |
| M9 | 17.79 | 94.52 | 16.82 | 8.80 |
| T0 | 27.92 | 94.83 | 26.47 | 9.10 |
| T1 | 28.77 | 92.62 | 26.65 | 7.00 |
| T2 | 39.67 | 93.80 | 37.21 | 8.40 |
| T3 | 34.19 | 96.05 | 32.84 | 8.40 |
| T4 | 28.48 | 96.02 | 27.34 | 7.40 |
| T5 | 32.10 | 93.70 | 30.08 | 8.80 |
| T6 | 32.60 | 96.05 | 31.31 | 6.70 |
| T7 | 26.11 | 93.38 | 24.38 | 8.90 |
| T8 | 23.40 | 94.84 | 22.19 | 8.90 |
| T9 | 18.47 | 94.84 | 17.52 | 8.80 |

Fri 21/7/89

| | | | |
|---|---|---|---|
| M0 | 28.09 | 96.39 | 27.07 |
| M1 | 26.03 | 94.21 | 24.52 |
| M2 | 23.64 | 96.21 | 22.74 |
| M3 | 38.80 | 94.49 | 36.66 |
| M4 | 36.46 | 94.94 | 34.62 |
| M5 | 27.78 | 94.04 | 26.12 |
| M6 | 33.00 | 94.26 | 31.11 |
| M7 | 31.45 | 95.68 | 30.09 |
| M8 | 28.62 | 95.78 | 27.42 |
| M9 | 18.19 | 95.32 | 17.34 |
| T0 | 28.64 | 96.01 | 27.50 |
| T1 | 29.12 | 93.11 | 27.11 |
| T2 | 36.54 | 93.80 | 34.28 |
| T3 | 37.09 | 96.58 | 35.83 |
| T4 | 28.63 | 96.43 | 27.61 |
| T5 | 32.93 | 94.14 | 31.00 |
| T6 | 33.22 | 96.54 | 32.07 |
| T7 | 26.51 | 93.75 | 24.85 |
| T8 | 23.58 | 96.20 | 22.69 |
| T9 | 18.51 | 96.17 | 17.80 |

Tue 25/7/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 28.47 | 96.56 | 27.49 | |
| M1 | 26.30 | 94.62 | 24.89 | |
| M2 | 23.33 | 96.35 | 22.48 | |
| M3 | 37.96 | 94.43 | 35.85 | |
| M4 | 36.54 | 95.16 | 34.77 | |
| M5 | 28.24 | 94.10 | 26.57 | |
| M6 | 33.75 | 94.35 | 31.84 | |
| M7 | 32.57 | 95.60 | 31.14 | |
| M8 | 27.80 | 95.74 | 26.62 | |
| M9 | 17.99 | 95.54 | 17.17 | |
| T0 | 28.67 | 95.85 | 27.48 | |
| T1 | 29.11 | 93.10 | 27.10 | |
| T2 | 36.33 | 94.74 | 34.42 | |
| T3 | 38.17 | 95.96 | 36.63 | |
| T4 | 30.22 | 96.65 | 29.21 | |
| T5 | 31.72 | 93.79 | 29.75 | |
| T6 | 32.23 | 98.28 | 31.67 | |
| T7 | 27.41 | 94.13 | 25.80 | |
| T8 | 23.67 | 96.07 | 22.74 | |
| T9 | 18.71 | 95.80 | 17.92 | |

Fri 28/7/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 29.22 | 95.80 | 27.99 | 9.05 |
| M1 | 26.46 | 94.12 | 24.91 | 8.50 |
| M2 | 23.55 | 96.39 | 22.70 | 7.55 |
| M3 | 40.36 | 94.36 | 38.08 | 8.70 |
| M4 | 39.44 | 94.78 | 37.38 | 7.30 |
| M5 | 28.88 | 93.92 | 27.12 | 7.40 |
| M6 | 34.39 | 93.65 | 32.21 | 7.30 |
| M7 | 29.97 | 96.17 | 28.82 | 8.30 |
| M8 | 28.38 | 96.11 | 27.28 | 8.00 |
| M9 | 18.08 | 95.82 | 17.33 | 7.70 |
| T0 | 28.79 | 94.93 | 27.33 | 8.70 |
| T1 | 28.69 | 93.42 | 26.80 | 8.75 |
| T2 | 38.91 | 94.22 | 36.66 | 8.50 |
| T3 | 36.57 | 95.83 | 35.05 | 8.30 |
| T4 | 30.09 | 95.83 | 28.83 | 6.40 |
| T5 | 33.47 | 93.84 | 31.41 | 8.70 |
| T6 | 35.18 | 95.92 | 33.74 | 6.10 |
| T7 | 26.90 | 93.67 | 25.20 | 8.70 |
| T8 | 23.58 | 95.76 | 22.58 | 8.65 |
| T9 | 18.58 | 96.09 | 17.86 | 8.00 |

JULY 1989
AVERAGE

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 26.91 | 98.07 | 26.26 | 8.20 |
| M1 | 25.54 | 94.12 | 24.05 | 8.78 |
| M2 | 22.64 | 95.59 | 21.65 | 8.54 |
| M3 | 38.54 | 94.30 | 36.34 | 7.87 |
| M4 | 37.97 | 95.60 | 36.30 | 6.75 |
| M5 | 28.33 | 93.98 | 26.62 | 8.35 |
| M6 | 34.55 | 94.08 | 32.50 | 7.58 |
| M7 | 31.66 | 95.28 | 30.16 | 8.39 |
| M8 | 28.91 | 95.29 | 27.55 | 8.56 |
| M9 | 18.04 | 94.69 | 17.09 | 8.70 |
| T0 | 27.48 | 95.06 | 26.13 | 8.98 |
| T1 | 28.76 | 93.12 | 26.78 | 8.71 |
| T2 | 37.90 | 94.41 | 35.78 | 7.98 |
| T3 | 36.45 | 96.07 | 35.02 | 8.58 |
| T4 | 28.37 | 96.09 | 27.26 | 7.74 |
| T5 | 32.19 | 94.15 | 30.31 | 8.87 |
| T6 | 33.05 | 96.57 | 31.91 | 7.36 |
| T7 | 26.57 | 93.82 | 24.93 | 8.87 |
| T8 | 23.73 | 95.29 | 22.62 | 8.92 |
| T9 | 18.76 | 95.27 | 17.88 | 8.84 |

JULY 1989
Std. Dev.

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 2.374 | 5.706 | 1.296 | 3.619 |
| M1 | 2.112 | 0.681 | 2.147 | 3.809 |
| M2 | 1.245 | 0.654 | 1.309 | 3.724 |
| M3 | 0.826 | 0.282 | 0.781 | 3.424 |
| M4 | 1.076 | 0.590 | 1.119 | 3.092 |
| M5 | 0.789 | 0.155 | 0.746 | 3.635 |
| M6 | 1.163 | 0.370 | 1.018 | 3.293 |
| M7 | 1.041 | 0.574 | 0.853 | 3.635 |
| M8 | 0.921 | 0.499 | 0.801 | 3.712 |
| M9 | 0.680 | 0.768 | 0.699 | 3.794 |
| T0 | 1.676 | 0.529 | 1.682 | 3.892 |
| T1 | 1.159 | 0.213 | 1.080 | 3.831 |
| T2 | 1.098 | 0.448 | 1.007 | 3.474 |
| T3 | 1.082 | 0.369 | 1.081 | 3.716 |
| T4 | 1.283 | 0.297 | 1.278 | 3.407 |
| T5 | 0.665 | 0.491 | 0.614 | 3.840 |
| T6 | 0.991 | 0.707 | 0.905 | 3.268 |
| T7 | 0.527 | 0.347 | 0.502 | 3.841 |
| T8 | 0.403 | 0.587 | 0.404 | 3.863 |
| T9 | 0.384 | 0.646 | 0.325 | 3.844 |

JULY 1989
AVERAGE *FEED VALUES*

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| F 2-20 | 20.46 | 96.42 | 19.73 | 4.59 |
| F 2-25 | 24.36 | 96.90 | 23.60 | 5.28 |
| F 2-30 | 30.49 | 97.20 | 29.63 | 4.63 |
| F 2-35 | 33.92 | 97.23 | 32.98 | 4.63 |
| F 2-40 | 38.81 | 97.23 | 37.73 | 4.64 |
| F 1-25 | 26.23 | 94.67 | 24.83 | 5.38 |
| F 1-30 | 29.74 | 94.75 | 28.18 | 5.53 |
| F 1-35 | 34.53 | 94.84 | 32.75 | 5.21 |
| F 1-40 | 39.96 | 95.06 | 37.99 | 5.18 |

JULY 1989
AVERAGE

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA AI/AP | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| F 2-20 | 0.00 | 0.00 | 0.62 | 0.62 | * | 0.00 | 0.00 | 2.93 | 2.93 |
| F 2-25 | 0.00 | 0.00 | 0.37 | 0.37 | * | 0.00 | 0.00 | 1.48 | 1.48 |
| F 2-30 | 0.00 | 0.00 | 0.49 | 0.49 | * | 0.00 | 0.00 | 1.50 | 1.50 |
| F 2-35 | 0.00 | 0.00 | 0.62 | 0.62 | * | 0.00 | 0.00 | 1.81 | 1.81 |
| F 2-40 | 0.00 | 0.00 | 0.58 | 0.58 | * | 0.00 | 0.00 | 1.49 | 1.49 |
| F 1-25 | 0.00 | 0.00 | 0.80 | 0.80 | * | 0.00 | 0.00 | 2.87 | 2.87 |
| F 1-30 | 0.00 | 0.00 | 0.64 | 0.64 | * | 0.00 | 0.00 | 2.12 | 2.12 |
| F 1-35 | 0.00 | 0.00 | 0.73 | 0.73 | * | 0.00 | 0.00 | 2.10 | 2.10 |
| F 1-40 | 0.00 | 0.00 | 0.72 | 0.72 | * | 0.00 | 0.00 | 1.80 | 1.80 |

* does not exist

Solids and pH Data

Wed 2/8/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 28.05 | 95.81 | 26.87 | 8.70 |
| M1 | 24.79 | 93.88 | 23.27 | 8.56 |
| M2 | 23.05 | 96.85 | 22.32 | 6.10 |
| M3 | 38.90 | 94.49 | 36.75 | 7.75 |
| M4 | 37.90 | 93.48 | 35.43 | 9.40 |
| M5 | 28.28 | 93.73 | 26.51 | 7.85 |
| M6 | 33.30 | 94.06 | 31.33 | 5.60 |
| M7 | 32.11 | 96.10 | 30.86 | 7.90 |
| M8 | 27.82 | 96.07 | 26.73 | 8.20 |
| M9 | 17.53 | 95.77 | 16.79 | 8.17 |
| | | | | |
| T0 | 25.95 | 95.92 | 24.89 | 8.80 |
| T1 | 27.45 | 93.54 | 25.68 | 8.90 |
| T2 | 37.43 | 94.71 | 35.45 | 7.75 |
| T3 | 37.06 | 95.66 | 35.45 | 8.10 |
| T4 | | | | |
| T5 | 31.52 | 92.97 | 29.30 | 9.20 |
| T6 | | | | |
| T7 | 24.57 | 93.55 | 22.99 | 8.40 |
| T8 | 22.50 | 96.13 | 21.63 | 8.35 |
| T9 | 24.05 | 97.14 | 23.37 | 7.55 |

Mon 7/8/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 30.76 | 96.28 | 29.61 | 6.10 |
| M1 | 25.77 | 93.99 | 24.23 | 8.75 |
| M2 | 26.69 | 94.92 | 25.34 | 9.25 |
| M3 | 40.94 | 95.19 | 38.98 | 8.00 |
| M4 | 41.12 | 94.44 | 38.84 | 9.05 |
| M5 | 29.33 | 94.21 | 27.63 | 7.00 |
| M6 | 35.48 | 92.59 | 32.86 | 9.70 |
| M7 | 33.63 | 96.09 | 32.31 | 7.55 |
| M8 | 28.78 | 96.47 | 27.77 | 7.80 |
| M9 | 18.51 | 96.05 | 17.78 | 7.25 |
| | | | | |
| T0 | 27.12 | 96.23 | 26.10 | 8.75 |
| T1 | 30.02 | 93.16 | 27.97 | 8.95 |
| T2 | 40.94 | 95.08 | 38.93 | 6.05 |
| T3 | 38.39 | 95.71 | 36.75 | 7.85 |
| T4 | | | | |
| T5 | 32.42 | 93.38 | 30.27 | 9.25 |
| T6 | | | | |
| T7 | 25.12 | 93.87 | 23.58 | 8.50 |
| T8 | 23.62 | 96.32 | 22.75 | 8.45 |
| T9 | 18.13 | 96.36 | 17.47 | 8.05 |

Solids and pH Data

Fri 11/8/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 28.43 | 96.31 | 27.38 | 5.50 |
| M1 | 25.11 | 93.49 | 23.48 | 8.90 |
| M2 | | | | |
| M3 | 40.04 | 94.26 | 37.75 | 7.80 |
| M4 | | | | |
| M5 | 28.82 | 94.21 | 27.15 | 6.70 |
| M6 | 34.04 | 92.35 | 31.44 | 9.15 |
| M7 | 40.10 | 96.89 | 38.85 | 7.90 |
| M8 | 29.00 | 96.15 | 27.89 | 6.85 |
| M9 | 20.18 | 96.83 | 19.54 | 6.40 |
| T0 | 28.09 | 96.44 | 27.09 | 8.50 |
| T1 | 29.47 | 93.28 | 27.49 | 8.20 |
| T2 | 39.78 | 94.59 | 37.63 | 8.50 |
| T3 | 37.86 | 96.46 | 36.52 | 7.20 |
| T4 | 27.31 | 94.24 | 25.74 | 9.60 |
| T5 | 31.88 | 93.16 | 29.70 | 9.00 |
| T6 | 31.34 | 94.55 | 29.63 | 9.70 |
| T7 | 25.15 | 93.54 | 23.52 | 8.30 |
| T8 | 22.91 | 96.06 | 22.00 | 8.30 |
| T9 | 18.96 | 96.25 | 18.25 | 8.50 |

Wed 16/8/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 28.40 | 95.44 | 27.11 | 8.90 |
| M1 | 24.39 | 94.12 | 22.95 | 8.50 |
| M2 | 25.78 | 94.27 | 24.30 | 9.30 |
| M3 | 40.13 | 94.53 | 37.93 | 6.70 |
| M4 | 36.02 | 95.02 | 34.23 | 7.30 |
| M5 | | | | 6.70 |
| M6 | 32.92 | 92.99 | 30.62 | 6.70 |
| M7 | 32.12 | 96.07 | 30.86 | 8.50 |
| M8 | 27.97 | 96.27 | 26.93 | 7.80 |
| M9 | 20.29 | 96.55 | 19.59 | 7.00 |
| T0 | 27.92 | 96.05 | 26.82 | 7.30 |
| T1 | 28.96 | 93.26 | 27.01 | 8.50 |
| T2 | 36.12 | 93.89 | 33.91 | 9.40 |
| T3 | 65.38 | 30.10 | 19.68 | 8.50 |
| T4 | 27.22 | 94.51 | 25.72 | 9.40 |
| T5 | 32.69 | 92.80 | 30.33 | 9.00 |
| T6 | 31.12 | 94.67 | 29.46 | 9.40 |
| T7 | 24.74 | 93.64 | 23.17 | 8.00 |
| T8 | 23.36 | 96.10 | 22.45 | 8.20 |
| T9 | 19.70 | 96.26 | 18.97 | 8.20 |

Solids and pH Data

Mon 21/8/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 25.82 | 94.31 | 24.35 | 9.00 |
| M1 | 24.69 | 93.35 | 23.05 | 8.35 |
| M2 | 23.66 | 93.70 | 22.17 | 9.30 |
| M3 | 40.66 | 93.53 | 38.03 | 7.05 |
| M4 | 33.49 | 94.90 | 31.78 | 7.10 |
| M5 | 27.77 | 92.62 | 25.72 | 9.05 |
| M6 | 32.46 | 91.94 | 29.84 | 6.70 |
| M7 | 32.02 | 95.57 | 30.60 | 8.75 |
| M8 | 26.94 | 95.25 | 25.66 | 9.05 |
| M9 | 20.72 | 94.95 | 19.68 | 8.00 |
| | | | | |
| T0 | 27.49 | 95.98 | 26.38 | 7.60 |
| T1 | 28.44 | 92.77 | 26.39 | 8.40 |
| T2 | 36.32 | 92.67 | 33.66 | 9.30 |
| T3 | 35.27 | 94.97 | 33.49 | 9.20 |
| T4 | 26.07 | 95.21 | 24.82 | 9.35 |
| T5 | 27.21 | 92.08 | 25.06 | 8.90 |
| T6 | 29.97 | 94.85 | 28.42 | 9.20 |
| T7 | 22.89 | 93.14 | 21.32 | 8.00 |
| T8 | 22.10 | 95.82 | 21.18 | 7.95 |
| T9 | 19.01 | 96.01 | 18.25 | 8.85 |

Fri 25/8/89

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 27.69 | 94.79 | 26.25 | 8.60 |
| M1 | 21.42 | 93.66 | 20.06 | 8.00 |
| M2 | 23.49 | 94.43 | 22.18 | 9.30 |
| M3 | 37.19 | 93.60 | 34.81 | 6.90 |
| M4 | 32.12 | 95.54 | 30.69 | 6.00 |
| M5 | 26.95 | 93.27 | 25.14 | 8.50 |
| M6 | 31.40 | 93.36 | 29.32 | 6.60 |
| M7 | 31.80 | 95.82 | 30.47 | 8.90 |
| M8 | 27.61 | 95.47 | 26.36 | 9.20 |
| M9 | 20.47 | 95.62 | 19.58 | 8.35 |
| | | | | |
| T0 | 27.85 | 96.11 | 26.77 | 7.65 |
| T1 | 27.01 | 92.83 | 25.08 | 8.10 |
| T2 | 34.22 | 94.46 | 32.32 | 8.80 |
| T3 | 36.67 | 95.58 | 35.05 | 8.86 |
| T4 | 27.38 | 95.65 | 26.19 | 8.90 |
| T5 | 30.72 | 93.05 | 28.59 | 8.45 |
| T6 | 29.15 | 95.39 | 27.80 | 9.00 |
| T7 | 24.04 | 93.35 | 22.44 | 8.55 |
| T8 | 22.13 | 96.08 | 21.26 | 8.20 |
| T9 | 19.66 | 96.20 | 18.91 | 8.30 |

AUGUST,89 Solids and pH Data
AVERAGE

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 28.19 | 95.49 | 26.93 | 7.80 |
| M1 | 24.36 | 93.75 | 22.84 | 8.51 |
| M2 | 24.53 | 94.83 | 23.26 | 8.65 |
| M3 | 39.64 | 94.27 | 37.37 | 7.37 |
| M4 | 36.13 | 94.68 | 34.19 | 7.77 |
| M5 | 28.23 | 93.61 | 26.43 | 7.63 |
| M6 | 33.27 | 92.88 | 30.90 | 7.41 |
| M7 | 33.63 | 96.09 | 32.32 | 8.23 |
| M8 | 28.02 | 95.95 | 26.89 | 8.15 |
| M9 | 19.62 | 95.96 | 18.83 | 7.53 |
| T0 | 27.41 | 96.12 | 26.34 | 8.10 |
| T1 | 28.56 | 93.14 | 26.60 | 8.51 |
| T2 | 37.47 | 94.23 | 35.32 | 8.30 |
| T3 | 37.05 | 95.68 | 35.45 | 8.24 |
| T4 | 27.00 | 94.90 | 25.62 | 9.31 |
| T5 | 31.07 | 92.91 | 28.88 | 8.97 |
| T6 | 30.39 | 94.86 | 28.83 | 9.33 |
| T7 | 24.42 | 93.52 | 22.84 | 8.29 |
| T8 | 22.77 | 96.08 | 21.88 | 8.24 |
| T9 | 19.92 | 96.37 | 19.20 | 8.24 |

AUGUST,89 Solids and pH Data
Std. Dev.

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| M0 | 1.448 | 0.737 | 1.557 | 1.431 |
| M1 | 1.386 | 0.273 | 1.311 | 0.288 |
| M2 | 1.433 | 1.082 | 1.314 | 1.275 |
| M3 | 1.272 | 0.573 | 1.318 | 0.500 |
| M4 | 3.197 | 0.692 | 2.871 | 1.273 |
| M5 | 0.826 | 0.605 | 0.911 | 0.884 |
| M6 | 1.275 | 0.692 | 1.154 | 1.484 |
| M7 | 2.955 | 0.407 | 2.982 | 0.508 |
| M8 | 0.699 | 0.437 | 0.773 | 0.801 |
| M9 | 1.177 | 0.619 | 1.128 | 0.700 |
| T0 | 0.723 | 0.174 | 0.722 | 0.601 |
| T1 | 1.063 | 0.267 | 1.005 | 0.322 |
| T2 | 2.278 | 0.785 | 2.313 | 1.145 |
| T3 | 10.606 | 24.445 | 5.974 | 0.660 |
| T4 | 0.535 | 0.558 | 0.496 | 0.256 |
| T5 | 1.840 | 0.409 | 1.808 | 0.261 |
| T6 | 0.889 | 0.323 | 0.752 | 0.259 |
| T7 | 0.778 | 0.228 | 0.776 | 0.221 |
| T8 | 0.580 | 0.146 | 0.583 | 0.157 |
| T9 | 1.923 | 0.360 | 1.928 | 0.399 |

# B4: ALKALINITY

## Alkalinity Data

Tues 11/7

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.00 | 0.29 | 0.53 | 0.24 | 0.83 | 0.00 | 1.04 | 1.91 | 0.87 |
| M1 | 0.00 | 0.35 | 0.75 | 0.40 | 1.14 | 0.00 | 1.22 | 2.61 | 1.39 |
| M2 | 0.05 | 0.44 | 0.78 | 0.34 | 0.78 | 0.21 | 1.87 | 3.33 | 1.45 |
| M3 | | | | | | | | | |
| M4 | 0.00 | 0.10 | 0.89 | 0.79 | 8.00 | 0.00 | 0.25 | 2.29 | 2.04 |
| M5 | 0.00 | 0.23 | 0.47 | 0.23 | 1.00 | 0.00 | 0.83 | 1.66 | 0.83 |
| M6 | 0.00 | 0.20 | 0.60 | 0.40 | 2.00 | 0.00 | 0.58 | 1.74 | 1.16 |
| M7 | 0.00 | 0.20 | 0.54 | 0.34 | 1.75 | 0.00 | 0.62 | 1.70 | 1.08 |
| M8 | 0.00 | 0.19 | 0.78 | 0.58 | 3.00 | 0.00 | 0.65 | 2.61 | 1.96 |
| M9 | | | | | | | | | |
| T0 | 0.14 | 0.65 | 1.02 | 0.37 | 0.57 | 0.50 | 2.34 | 3.67 | 1.34 |
| T1 | 0.10 | 0.64 | 0.98 | 0.34 | 0.54 | 0.32 | 2.05 | 3.16 | 1.10 |
| T2 | 0.00 | 0.20 | 1.23 | 1.03 | 5.25 | 0.00 | 0.52 | 3.27 | 2.75 |
| T3 | 0.00 | 0.35 | 0.65 | 0.30 | 0.86 | 0.00 | 0.96 | 1.79 | 0.83 |
| T4 | 0.00 | 0.15 | 0.87 | 0.73 | 5.00 | 0.00 | 0.51 | 3.03 | 2.53 |
| T5 | 0.00 | 0.34 | 0.82 | 0.48 | 1.43 | 0.00 | 1.08 | 2.62 | 1.54 |
| T6 | 0.00 | 0.21 | 1.09 | 0.88 | 4.25 | 0.00 | 0.62 | 3.25 | 2.63 |
| T7 | 0.05 | 0.45 | 0.80 | 0.35 | 0.78 | 0.20 | 1.76 | 3.13 | 1.37 |
| T8 | 0.00 | 0.30 | 0.50 | 0.20 | 0.67 | 0.00 | 1.24 | 2.07 | 0.83 |
| T9 | 0.10 | 0.84 | 1.04 | 0.20 | 0.24 | 0.54 | 4.57 | 5.65 | 1.08 |

Fri 14/7/

M0
M1
M2
M3
M4
M5
M6
M7
M8
M9

T0
T1
T2
T3
T4
T5
T6
T7
T8
T9

Tu 4/7/89

# Alkalinity Data

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.05 | 0.45 | 0.84 | 0.40 | 0.89 | 0.23 | 2.11 | 3.99 | 1.88 |
| M1 | 0.05 | 0.61 | 1.01 | 0.40 | 0.67 | 0.23 | 2.76 | 4.60 | 1.84 |
| M2 | 0.05 | 0.39 | 0.58 | 0.19 | 0.50 | 0.24 | 1.95 | 2.92 | 0.97 |
| M3 | 0.00 | 0.21 | 0.54 | 0.32 | 1.50 | 0.00 | 0.57 | 1.43 | 0.86 |
| M4 | 0.00 | 0.16 | 0.63 | 0.47 | 3.00 | 0.00 | 0.41 | 1.66 | 1.24 |
| M5 | 0.00 | 0.15 | 0.44 | 0.29 | 2.00 | 0.00 | 0.49 | 1.46 | 0.98 |
| M6 | 0.00 | 0.21 | 0.70 | 0.48 | 2.25 | 0.00 | 0.58 | 1.88 | 1.30 |
| M7 | 0.00 | 0.15 | 0.53 | 0.39 | 2.67 | 0.00 | 0.44 | 1.62 | 1.18 |
| M8 | 0.00 | 0.96 | 1.52 | 0.56 | 0.58 | 0.00 | 3.19 | 5.04 | 1.85 |
| M9 | 0.08 | 0.75 | 1.05 | 0.30 | 0.40 | 0.44 | 4.40 | 5.16 | 1.76 |
| T0 | 0.14 | 0.66 | 1.14 | 0.47 | 0.71 | 0.58 | 2.70 | 4.63 | 1.93 |
| T1 | 0.05 | 0.53 | 0.86 | 0.33 | 0.54 | 0.18 | 1.94 | 3.17 | 1.23 |
| T2 | 0.00 | 0.55 | 1.21 | 0.65 | 1.18 | 0.00 | 1.45 | 3.15 | 1.71 |
| T3 | 0.00 | 0.29 | 0.87 | 0.58 | 2.00 | 0.00 | 0.81 | 2.43 | 1.62 |
| T4 | 0.00 | 0.78 | 1.55 | 0.78 | 1.00 | 0.00 | 2.91 | 5.83 | 2.91 |
| T5 | 0.00 | 0.25 | 0.54 | 0.30 | 1.20 | 0.00 | 0.77 | 1.69 | 0.92 |
| T6 | 0.00 | 0.15 | 0.59 | 0.44 | 3.00 | 0.00 | 0.47 | 1.87 | 1.40 |
| T7 | 0.05 | 0.64 | 0.74 | 0.10 | 0.15 | 0.18 | 2.37 | 2.73 | 0.36 |
| T8 | | | | | | | | | |
| T9 | 0.23 | 0.88 | 1.30 | 0.42 | 0.47 | 1.18 | 4.50 | 6.63 | 2.13 |

Fri 7/7/8

M0
M1
M2
M3
M4
M5
M6
M7
M8
M9

T0
T1
T2
T3
T4
T5
T6
T7
T8
T9

Tues 18/7

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.00 | 0.20 | 0.82 | 0.62 | 3.13 | 0.00 | 0.72 | 2.99 | 2.26 |
| M1 | 0.00 | 0.44 | 1.03 | 0.59 | 1.33 | 0.00 | 1.71 | 3.99 | 2.28 |
| M2 | 0.00 | 0.36 | 0.87 | 0.51 | 1.40 | 0.00 | 1.58 | 3.78 | 2.21 |
| M3 | 0.00 | 0.17 | 0.77 | 0.50 | 3.57 | 0.00 | 0.43 | 1.98 | 1.55 |
| M4 | | | | | | | | | |
| M5 | 0.00 | 0.37 | 0.89 | 0.53 | 1.44 | 0.00 | 1.32 | 3.21 | 1.89 |
| M6 | 0.00 | 0.20 | 1.16 | 0.96 | 4.75 | 0.00 | 0.58 | 3.34 | 2.76 |
| M7 | 0.00 | 0.33 | 0.95 | 0.62 | 1.86 | 0.00 | 1.05 | 3.01 | 1.96 |
| M8 | 0.00 | 0.46 | 1.02 | 0.56 | 1.22 | 0.00 | 1.63 | 3.63 | 1.99 |
| M9 | 0.02 | 0.88 | 1.42 | 0.53 | 0.61 | 0.13 | 4.96 | 7.96 | 3.00 |
| | | | | | | | | | |
| T0 | 0.03 | 1.02 | 1.42 | 0.40 | 0.39 | 0.10 | 3.66 | 5.10 | 1.44 |
| T1 | 0.08 | 0.86 | 1.54 | 0.68 | 0.79 | 0.27 | 3.00 | 5.37 | 2.37 |
| T2 | 0.00 | 0.44 | 3.22 | 2.78 | 6.33 | 0.00 | 1.11 | 8.12 | 7.02 |
| T3 | 0.00 | 0.40 | 1.46 | 1.05 | 2.63 | 0.00 | 1.17 | 4.26 | 3.08 |
| T4 | 0.00 | 0.22 | 2.03 | 1.81 | 8.22 | 0.00 | 0.77 | 7.13 | 6.36 |
| T5 | 0.00 | 0.50 | 1.41 | 0.80 | 1.33 | 0.00 | 1.88 | 4.39 | 2.51 |
| T6 | 0.00 | 0.35 | 3.11 | 2.77 | 8.00 | 0.00 | 1.06 | 9.54 | 8.48 |
| T7 | 0.00 | 0.86 | 1.51 | 0.65 | 0.75 | 0.00 | 3.29 | 5.77 | 2.47 |
| T8 | 0.00 | 0.87 | 1.55 | 0.67 | 0.77 | 0.00 | 3.73 | 6.60 | 2.88 |
| T9 | 0.17 | 1.28 | 1.81 | 0.52 | 0.41 | 0.90 | 6.95 | 9.79 | 2.83 |

Fri 21/7/

M0
M1
M2
M3
M4
M5
M6
M7
M8
M9

T0
T1
T2
T3
T4
T5
T6
T7
T8
T9

Tue 25/7/

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | | | | | | | | | |
| M1 | | | | | | | | | |
| M2 | | | | | | | | | |
| M3 | | | | | | | | | |
| M4 | | | | | | | | | |
| M5 | | | | | | | | | |
| M6 | | | | | | | | | |
| M7 | | | | | | | | | |
| M8 | | | | | | | | | |
| M9 | | | | | | | | | |
| | | | | | | | | | |
| T0 | | | | | | | | | |
| T1 | | | | | | | | | |
| T2 | | | | | | | | | |
| T3 | | | | | | | | | |
| T4 | | | | | | | | | |
| T5 | | | | | | | | | |
| T6 | | | | | | | | | |
| T7 | | | | | | | | | |
| T8 | | | | | | | | | |
| T9 | | | | | | | | | |

Fri 28/7/

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.08 | 0.98 | 3.13 | 2.15 | 2.20 | 0.27 | 3.34 | 10.70 | 7.35 |
| M1 | 0.00 | 0.15 | 0.84 | 0.70 | 4.75 | 0.00 | 0.55 | 3.19 | 2.63 |
| M2 | 0.00 | 0.15 | 0.84 | 0.69 | 4.50 | 0.00 | 0.65 | 3.57 | 2.92 |
| M3 | 0.00 | 0.35 | 1.47 | 1.13 | 3.22 | 0.00 | 0.87 | 3.65 | 2.79 |
| M4 | 0.00 | 0.67 | 4.90 | 4.24 | 6.35 | 0.00 | 1.69 | 12.43 | 10.74 |
| M5 | 0.00 | 0.20 | 0.71 | 0.51 | 2.60 | 0.00 | 0.68 | 2.46 | 1.78 |
| M6 | 0.00 | 0.28 | 2.10 | 1.82 | 6.57 | 0.00 | 0.81 | 5.11 | 5.30 |
| M7 | 0.00 | 0.27 | 0.73 | 0.46 | 1.71 | 0.00 | 0.89 | 2.42 | 1.53 |
| M8 | 0.00 | 0.27 | 0.68 | 0.42 | 1.57 | 0.00 | 0.94 | 2.41 | 1.47 |
| M9 | 0.00 | 0.65 | 1.23 | 0.57 | 0.88 | 0.00 | 3.62 | 6.79 | 3.17 |
| | | | | | | | | | |
| T0 | 0.15 | 0.73 | 1.25 | 0.51 | 0.70 | 0.51 | 2.55 | 4.34 | 1.79 |
| T1 | 0.24 | 1.45 | 1.77 | 0.32 | 0.22 | 0.84 | 5.06 | 6.18 | 1.12 |
| T2 | 0.08 | 0.74 | 2.44 | 1.71 | 2.32 | 0.20 | 1.89 | 6.28 | 4.39 |
| T3 | 0.00 | 0.35 | 0.92 | 0.58 | 1.67 | 0.00 | 0.95 | 2.52 | 1.58 |
| T4 | 0.00 | 0.94 | 7.42 | 6.48 | 6.32 | 0.00 | 3.12 | 24.67 | 21.55 |
| T5 | 0.00 | 0.82 | 1.61 | 0.78 | 0.95 | 0.00 | 2.46 | 4.80 | 2.34 |
| T6 | 0.00 | 0.42 | 5.71 | 5.29 | 12.62 | 0.00 | 1.19 | 16.23 | 15.04 |
| T7 | 0.04 | 0.60 | 1.20 | 0.60 | 1.00 | 0.15 | 2.22 | 4.44 | 2.22 |
| T8 | 0.07 | 0.95 | 1.41 | 0.46 | 0.48 | 0.30 | 4.05 | 6.00 | 1.95 |
| T9 | 0.00 | 0.99 | 1.42 | 0.43 | 0.43 | 0.00 | 5.32 | 7.62 | 2.30 |

JULY 1989
AVERAGE

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA AI/AP | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.03 | 0.48 | 1.33 | 0.85 | 1.78 | 0.13 | 1.81 | 4.90 | 3.09 |
| M1 | 0.01 | 0.39 | 0.91 | 0.52 | 1.35 | 0.06 | 1.56 | 3.60 | 2.04 |
| M2 | 0.02 | 0.34 | 0.77 | 0.43 | 1.29 | 0.11 | 1.51 | 3.40 | 1.89 |
| M3 | 0.00 | 0.24 | 0.93 | 0.68 | 2.80 | 0.00 | 0.62 | 2.35 | 1.73 |
| M4 | 0.00 | 0.31 | 2.14 | 1.83 | 5.96 | 0.00 | 0.79 | 5.46 | 4.67 |
| M5 | 0.00 | 0.24 | 0.63 | 0.39 | 1.66 | 0.00 | 0.83 | 2.20 | 1.37 |
| M6 | 0.00 | 0.22 | 1.14 | 0.92 | 4.10 | 0.00 | 0.64 | 3.27 | 2.63 |
| M7 | 0.00 | 0.24 | 0.69 | 0.45 | 1.92 | 0.00 | 0.75 | 2.19 | 1.44 |
| M8 | 0.00 | 0.47 | 1.00 | 0.53 | 1.13 | 0.00 | 1.60 | 3.42 | 1.82 |
| M9 | 0.02 | 0.57 | 0.92 | 0.35 | 0.62 | 0.14 | 3.24 | 5.23 | 1.98 |
| T0 | 0.11 | 0.77 | 1.21 | 0.44 | 0.57 | 0.42 | 2.81 | 4.44 | 1.62 |
| T1 | 0.12 | 0.87 | 1.29 | 0.42 | 0.48 | 0.40 | 3.01 | 4.47 | 1.46 |
| T2 | 0.02 | 0.48 | 2.03 | 1.54 | 3.21 | 0.05 | 1.24 | 5.21 | 3.97 |
| T3 | 0.00 | 0.35 | 0.97 | 0.63 | 1.81 | 0.00 | 0.97 | 2.75 | 1.78 |
| T4 | 0.00 | 0.52 | 2.97 | 2.45 | 4.71 | 0.00 | 1.83 | 10.16 | 8.34 |
| T5 | 0.00 | 0.50 | 1.10 | 0.59 | 1.18 | 0.00 | 1.55 | 3.38 | 1.83 |
| T6 | 0.00 | 0.28 | 2.63 | 2.35 | 8.37 | 0.00 | 0.83 | 7.72 | 6.89 |
| T7 | 0.03 | 0.64 | 1.06 | 0.42 | 0.66 | 0.13 | 2.41 | 4.02 | 1.61 |
| T8 | 0.02 | 0.53 | 0.86 | 0.33 | 0.63 | 0.07 | 2.25 | 3.67 | 1.41 |
| T9 | 0.12 | 1.00 | 1.39 | 0.39 | 0.39 | 0.66 | 5.34 | 7.42 | 2.09 |

JULY 1989
Std. Dev.

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA AI/AP | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.033 | 0.301 | 1.044 | 0.761 | 0.958 | 0.126 | 1.025 | 3.428 | 2.513 |
| M1 | 0.022 | 0.166 | 0.117 | 0.127 | 1.621 | 0.100 | 0.805 | 0.759 | 0.466 |
| M2 | 0.024 | 0.110 | 0.111 | 0.184 | 1.596 | 0.114 | 0.516 | 0.320 | 0.741 |
| M3 | 0.000 | 0.125 | 0.530 | 0.413 | 0.905 | 0.000 | 0.312 | 1.308 | 1.020 |
| M4 | 0.000 | 0.255 | 1.956 | 1.704 | 2.080 | 0.000 | 0.643 | 4.935 | 4.301 |
| M5 | 0.000 | 0.081 | 0.185 | 0.130 | 0.601 | 0.000 | 0.307 | 0.694 | 0.471 |
| M6 | 0.000 | 0.032 | 0.595 | 0.566 | 1.884 | 0.000 | 0.098 | 1.757 | 1.665 |
| M7 | 0.000 | 0.071 | 0.172 | 0.105 | 0.390 | 0.000 | 0.237 | 0.568 | 0.343 |
| M8 | 0.000 | 0.300 | 0.324 | 0.065 | 0.887 | 0.000 | 0.983 | 1.041 | 0.206 |
| M9 | 0.031 | 0.340 | 0.549 | 0.228 | 0.195 | 0.180 | 1.932 | 3.085 | 1.267 |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| T0 | 0.050 | 0.150 | 0.148 | 0.056 | 0.128 | 0.190 | 0.506 | 0.518 | 0.242 |
| T1 | 0.074 | 0.357 | 0.380 | 0.151 | 0.207 | 0.259 | 1.250 | 1.336 | 0.527 |
| T2 | 0.034 | 0.196 | 0.853 | 0.808 | 2.096 | 0.086 | 0.500 | 2.098 | 2.003 |
| T3 | 0.000 | 0.040 | 0.296 | 0.271 | 0.638 | 0.000 | 0.130 | 0.914 | 0.817 |
| T4 | 0.000 | 0.343 | 2.603 | 2.369 | 2.726 | 0.000 | 1.194 | 8.504 | 7.774 |
| T5 | 0.000 | 0.227 | 0.429 | 0.212 | 0.180 | 0.000 | 0.665 | 1.270 | 0.637 |
| T6 | 0.000 | 0.108 | 2.014 | 1.910 | 3.746 | 0.000 | 0.300 | 5.699 | 5.412 |
| T7 | 0.021 | 0.146 | 0.310 | 0.218 | 0.314 | 0.078 | 0.558 | 1.191 | 0.825 |
| T8 | 0.031 | 0.397 | 0.642 | 0.255 | 0.120 | 0.130 | 1.696 | 2.742 | 1.092 |
| T9 | 0.086 | 0.173 | 0.276 | 0.119 | 0.091 | 0.442 | 0.988 | 1.533 | 0.638 |

# Alkalinity Data

Wed 2/8/8

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.00 | 0.47 | 2.70 | 2.23 | 4.70 | 0.00 | 1.69 | 9.63 | 7.94 |
| M1 | 0.00 | 0.25 | 0.53 | 0.44 | 1.80 | 0.00 | 0.99 | 2.77 | 1.78 |
| M2 | 0.00 | 0.09 | 1.32 | 1.23 | 13.50 | 0.00 | 0.39 | 5.73 | 5.33 |
| M3 | 0.00 | 0.29 | 1.78 | 1.49 | 5.08 | 0.00 | 0.75 | 4.59 | 3.83 |
| M4 | 0.88 | 4.27 | 11.63 | 7.36 | 1.72 | 2.33 | 11.26 | 30.68 | 19.42 |
| M5 | 0.00 | 0.20 | 0.55 | 0.35 | 1.75 | 0.00 | 0.71 | 1.94 | 1.23 |
| M6 | 0.00 | 0.02 | 2.52 | 2.50 | 103.00 | 0.00 | 0.07 | 7.58 | 7.51 |
| M7 | 0.00 | 0.23 | 0.68 | 0.45 | 2.00 | 0.00 | 0.70 | 2.11 | 1.41 |
| M8 | 0.00 | 0.19 | 0.56 | 0.37 | 2.00 | 0.00 | 0.67 | 2.00 | 1.34 |
| M9 | 0.00 | 0.20 | 0.67 | 0.47 | 2.38 | 0.00 | 1.12 | 3.79 | 2.67 |
| T0 | 0.03 | 0.99 | 1.44 | 0.46 | 0.46 | 0.10 | 3.80 | 5.56 | 1.76 |
| T1 | 0.15 | 1.02 | 2.61 | 1.58 | 1.55 | 0.56 | 3.73 | 9.50 | 5.77 |
| T2 | 0.00 | 0.40 | 2.37 | 1.97 | 4.94 | 0.00 | 1.07 | 6.33 | 5.26 |
| T3 | 0.00 | 0.30 | 1.00 | 0.70 | 2.33 | 0.00 | 0.81 | 2.69 | 1.89 |
| T4 | | | | | | | | | |
| T5 | 0.88 | 2.43 | 3.39 | 0.95 | 0.39 | 2.80 | 7.72 | 10.75 | 3.03 |
| T6 | | | | | | | | | |
| T7 | 0.02 | 0.44 | 0.85 | 0.41 | 0.94 | 0.10 | 1.79 | 3.47 | 1.69 |
| T8 | 0.05 | 0.87 | 1.29 | 0.41 | 0.47 | 0.22 | 3.88 | 5.71 | 1.83 |
| T9 | 0.00 | 0.92 | 1.30 | 0.37 | 0.41 | 0.00 | 3.84 | 5.40 | 1.56 |

Mon 7/8/9

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.00 | 0.12 | 2.28 | 2.16 | 17.40 | 0.00 | 0.40 | 7.42 | 7.02 |
| M1 | 0.00 | 0.26 | 0.71 | 0.45 | 1.73 | 0.00 | 1.01 | 2.76 | 1.75 |
| M2 | 0.10 | 1.43 | 4.76 | 3.33 | 2.33 | 0.36 | 5.35 | 17.84 | 12.49 |
| M3 | 0.00 | 0.21 | 1.40 | 1.19 | 5.56 | 0.00 | 0.52 | 3.43 | 2.90 |
| M4 | 0.00 | 1.09 | 7.09 | 5.99 | 5.48 | 0.00 | 2.66 | 17.24 | 14.58 |
| M5 | 0.00 | 0.09 | 0.81 | 0.71 | 7.50 | 0.00 | 0.32 | 2.75 | 2.42 |
| M6 | 0.56 | 2.85 | 7.71 | 4.86 | 1.70 | 1.58 | 8.03 | 21.73 | 13.70 |
| M7 | 0.00 | 0.10 | 0.47 | 0.37 | 3.75 | 0.00 | 0.29 | 1.40 | 1.10 |
| M8 | 0.00 | 0.12 | 0.50 | 0.38 | 3.20 | 0.00 | 0.41 | 1.72 | 1.31 |
| M9 | 0.00 | 0.22 | 0.72 | 0.50 | 2.33 | 0.00 | 1.16 | 3.87 | 2.71 |
| T0 | 0.12 | 0.80 | 1.22 | 0.42 | 0.53 | 0.43 | 2.93 | 4.48 | 1.55 |
| T1 | 0.14 | 0.80 | 1.34 | 0.54 | 0.68 | 0.47 | 2.66 | 4.45 | 1.80 |
| T2 | 0.00 | 0.35 | 4.31 | 3.96 | 11.27 | 0.00 | 0.86 | 10.53 | 9.67 |
| T3 | 0.00 | 0.28 | 1.34 | 1.06 | 3.83 | 0.00 | 0.72 | 3.49 | 2.77 |
| T4 | | | | | | | | | |
| T5 | 0.46 | 1.73 | 2.54 | 0.81 | 0.47 | 1.42 | 5.34 | 7.83 | 2.49 |
| T6 | | | | | | | | | |
| T7 | 0.05 | 0.54 | 0.92 | 0.38 | 0.70 | 0.19 | 2.16 | 3.67 | 1.50 |
| T8 | 0.02 | 0.72 | 1.17 | 0.46 | 0.63 | 0.10 | 3.04 | 4.97 | 1.93 |
| T9 | 0.00 | 0.77 | 1.20 | 0.43 | 0.56 | 0.00 | 4.23 | 6.60 | 2.38 |

Alkalinity Data

Fri 11/8/

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.00 | 0.00 | 1.53 | 1.53 | | 0.00 | 0.00 | 5.37 | 5.37 |
| M1 | 0.04 | 0.37 | 0.56 | 0.19 | 0.50 | 0.15 | 1.48 | 2.23 | 0.74 |
| M2 | | | | | | | | | |
| M3 | 0.00 | 0.19 | 0.98 | 0.79 | 4.20 | 0.00 | 0.47 | 2.44 | 1.97 |
| M4 | | | | | | | | | |
| M5 | 0.00 | 0.11 | 0.88 | 0.76 | 6.67 | 0.00 | 0.40 | 3.05 | 2.65 |
| M6 | 0.12 | 1.42 | 7.41 | 5.99 | 4.22 | 0.35 | 4.17 | 21.76 | 17.60 |
| M7 | 0.00 | 0.30 | 0.83 | 0.53 | 1.75 | 0.00 | 0.75 | 2.06 | 1.31 |
| M8 | 0.00 | 0.20 | 0.88 | 0.68 | 3.40 | 0.00 | 0.69 | 3.04 | 2.35 |
| M9 | 0.00 | 0.23 | 1.10 | 0.87 | 3.83 | 0.00 | 1.12 | 5.43 | 4.31 |
| T0 | 0.05 | 0.37 | 0.63 | 0.26 | 0.71 | 0.19 | 1.30 | 2.23 | 0.93 |
| T1 | 0.00 | 0.37 | 0.70 | 0.33 | 0.89 | 0.00 | 1.25 | 2.37 | 1.11 |
| T2 | 0.08 | 0.76 | 2.67 | 1.90 | 2.50 | 0.19 | 1.92 | 6.70 | 4.79 |
| T3 | 0.00 | 0.19 | 1.19 | 1.00 | 5.20 | 0.00 | 0.51 | 3.15 | 2.64 |
| T4 | 1.63 | 4.54 | 5.59 | 1.06 | 0.23 | 5.98 | 16.61 | 20.48 | 3.87 |
| T5 | 0.36 | 1.04 | 5.00 | 3.96 | 3.81 | 1.12 | 3.26 | 15.70 | 12.43 |
| T6 | 2.16 | 5.25 | 6.78 | 1.53 | 0.29 | 6.89 | 16.76 | 21.63 | 4.87 |
| T7 | 0.00 | 0.25 | 0.41 | 0.16 | 0.64 | 0.00 | 0.99 | 1.63 | 0.63 |
| T8 | 0.00 | 0.29 | 0.55 | 0.26 | 0.90 | 0.00 | 1.27 | 2.41 | 1.14 |
| T9 | 0.05 | 0.62 | 0.91 | 0.29 | 0.46 | 0.25 | 3.27 | 4.78 | 1.51 |

Wed 16/8/

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.14 | 1.10 | 4.86 | 3.76 | 3.42 | 0.51 | 3.87 | 17.11 | 13.24 |
| M1 | 0.04 | 0.40 | 0.89 | 0.48 | 1.20 | 0.17 | 1.65 | 3.63 | 1.98 |
| M2 | 0.52 | 2.62 | 6.07 | 3.45 | 1.31 | 2.01 | 10.17 | 23.54 | 13.37 |
| M3 | 0.00 | 0.12 | 1.59 | 1.47 | 12.33 | 0.00 | 0.30 | 3.97 | 3.67 |
| M4 | 0.00 | 0.39 | 5.55 | 5.16 | 13.25 | 0.00 | 1.08 | 15.40 | 14.32 |
| M5 | 0.00 | 0.50 | 2.32 | 1.83 | 3.69 | | | | |
| M6 | 0.00 | 0.59 | 5.87 | 5.27 | 8.88 | 0.00 | 1.80 | 17.82 | 16.02 |
| M7 | 0.08 | 0.78 | 1.06 | 0.27 | 0.35 | 0.24 | 2.44 | 3.30 | 0.85 |
| M8 | 0.00 | 0.26 | 0.96 | 0.70 | 2.71 | 0.00 | 0.93 | 3.44 | 2.51 |
| M9 | 0.00 | 0.22 | 1.08 | 0.86 | 3.92 | 0.00 | 1.08 | 5.30 | 4.22 |
| T0 | 0.00 | 0.21 | 0.86 | 0.65 | 3.17 | 0.00 | 0.74 | 3.08 | 2.34 |
| T1 | 0.04 | 0.50 | 1.00 | 0.50 | 1.00 | 0.12 | 1.72 | 3.44 | 1.72 |
| T2 | 0.67 | 2.90 | 7.09 | 4.20 | 1.45 | 1.85 | 8.02 | 19.64 | 11.62 |
| T3 | 0.07 | 0.76 | 2.14 | 1.38 | 1.82 | 0.11 | 1.16 | 3.28 | 2.12 |
| T4 | 1.67 | 4.37 | 6.27 | 1.90 | 0.43 | 6.14 | 16.07 | 23.04 | 6.97 |
| T5 | 0.27 | 1.20 | 1.85 | 0.65 | 0.54 | 0.84 | 3.67 | 5.66 | 1.99 |
| T6 | 1.25 | 4.43 | 6.67 | 2.23 | 0.50 | 4.02 | 14.24 | 21.42 | 7.18 |
| T7 | 0.00 | 0.31 | 0.62 | 0.31 | 1.00 | 0.00 | 1.26 | 2.52 | 1.26 |
| T8 | 0.00 | 0.39 | 0.74 | 0.35 | 0.90 | 0.00 | 1.66 | 3.15 | 1.49 |
| T9 | 0.00 | 0.55 | 0.99 | 0.44 | 0.80 | 0.00 | 2.78 | 5.01 | 2.22 |

Alkalinity Data

Mon 21/8/

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.18 | 2.38 | 7.30 | 4.91 | 2.06 | 0.70 | 9.23 | 28.26 | 19.03 |
| M1 | 0.07 | 0.75 | 0.99 | 0.23 | 0.31 | 0.29 | 3.05 | 3.99 | 0.94 |
| M2 | 0.44 | 3.21 | 5.47 | 2.26 | 0.71 | 1.86 | 13.56 | 23.13 | 9.56 |
| M3 | 0.00 | 0.35 | 2.56 | 2.21 | 6.38 | 0.00 | 0.85 | 6.29 | 5.44 |
| M4 | 0.00 | 0.62 | 4.62 | 4.00 | 6.50 | 0.00 | 1.84 | 13.78 | 11.94 |
| M5 | 0.13 | 1.76 | 3.91 | 2.15 | 1.23 | 0.48 | 6.32 | 14.08 | 7.75 |
| M6 | 0.00 | 0.76 | 6.46 | 5.70 | 7.48 | 0.00 | 2.35 | 19.90 | 17.55 |
| M7 | 0.07 | 0.83 | 1.39 | 0.56 | 0.68 | 0.21 | 2.58 | 4.34 | 1.76 |
| M8 | 0.43 | 2.37 | 3.47 | 1.10 | 0.46 | 1.61 | 8.79 | 12.88 | 4.09 |
| M9 | 0.00 | 1.91 | 3.54 | 1.63 | 0.86 | 0.00 | 9.22 | 17.10 | 7.88 |
| T0 | 0.00 | 0.31 | 1.75 | 1.45 | 4.71 | 0.00 | 1.12 | 6.38 | 5.26 |
| T1 | 0.04 | 0.00 | 0.98 | 0.99 | | 0.15 | 0.00 | 3.43 | 3.43 |
| T2 | 0.95 | 3.56 | 6.61 | 3.03 | 0.85 | 2.62 | 9.85 | 18.21 | 8.35 |
| T3 | 0.59 | 1.99 | 3.40 | 1.41 | 0.71 | 1.66 | 5.64 | 9.63 | 3.98 |
| T4 | 0.72 | 2.79 | 3.92 | 1.12 | 0.40 | 2.74 | 10.71 | 15.02 | 4.31 |
| T5 | 0.12 | 1.13 | 1.79 | 0.66 | 0.59 | 0.43 | 4.14 | 6.57 | 2.43 |
| T6 | 0.60 | 2.52 | 3.96 | 1.44 | 0.57 | 2.01 | 8.39 | 13.20 | 4.81 |
| T7 | 0.00 | 0.21 | 0.52 | 0.30 | 1.43 | 0.00 | 0.93 | 2.25 | 1.32 |
| T8 | 0.00 | 0.27 | 0.92 | 0.65 | 2.44 | 0.00 | 1.21 | 4.17 | 2.96 |
| T9 | 0.13 | 0.93 | 1.17 | 0.24 | 0.26 | 0.70 | 4.89 | 6.17 | 1.28 |

Fri 25/8/

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.03 | 0.97 | 5.53 | 4.57 | 4.73 | 0.12 | 3.49 | 19.98 | 16.49 |
| M1 | 0.00 | 0.43 | 0.67 | 0.23 | 0.54 | 0.00 | 2.02 | 3.11 | 1.09 |
| M2 | 0.63 | 2.78 | 4.55 | 1.77 | 0.64 | 2.69 | 11.83 | 19.35 | 7.53 |
| M3 | 0.00 | 0.20 | 1.82 | 1.62 | 8.25 | 0.00 | 0.53 | 4.88 | 4.35 |
| M4 | 0.00 | 0.14 | 3.16 | 3.02 | 21.67 | 0.00 | 0.43 | 9.84 | 9.40 |
| M5 | 0.02 | 0.78 | 3.00 | 2.22 | 2.83 | 0.08 | 2.90 | 11.13 | 8.23 |
| M6 | 0.00 | 0.39 | 4.78 | 4.39 | 11.13 | 0.00 | 1.26 | 15.23 | 13.98 |
| M7 | 0.09 | 0.88 | 1.70 | 0.83 | 0.95 | 0.30 | 2.75 | 5.35 | 2.60 |
| M8 | 0.45 | 1.91 | 3.33 | 1.42 | 0.74 | 1.62 | 6.90 | 12.05 | 5.14 |
| M9 | 0.00 | 0.62 | 2.64 | 2.02 | 3.24 | 0.00 | 3.04 | 12.89 | 9.85 |
| T0 | 0.00 | 0.22 | 1.78 | 1.56 | 7.20 | 0.00 | 0.78 | 6.38 | 5.60 |
| T1 | 0.00 | 0.40 | 0.82 | 0.42 | 1.05 | 0.00 | 1.47 | 3.02 | 1.55 |
| T2 | 0.35 | 2.38 | 4.63 | 2.25 | 0.94 | 1.03 | 6.96 | 13.54 | 6.58 |
| T3 | 0.43 | 2.01 | 3.90 | 1.89 | 0.94 | 1.17 | 5.47 | 10.62 | 5.15 |
| T4 | 0.30 | 1.92 | 4.05 | 2.13 | 1.11 | 1.09 | 7.00 | 14.78 | 7.78 |
| T5 | 0.02 | 0.81 | 1.56 | 0.75 | 0.92 | 0.07 | 2.64 | 5.07 | 2.43 |
| T6 | 0.55 | 2.37 | 3.94 | 1.57 | 0.66 | 1.89 | 8.14 | 13.52 | 5.38 |
| T7 | 0.04 | 0.74 | 1.31 | 0.57 | 0.77 | 0.18 | 3.08 | 5.46 | 2.38 |
| T8 | 0.00 | 0.55 | 1.18 | 0.64 | 1.17 | 0.00 | 2.47 | 5.34 | 2.88 |
| T9 | 0.00 | 0.62 | 1.07 | 0.45 | 0.73 | 0.00 | 3.13 | 5.43 | 2.30 |

AUGUST,89 Alkalinity Data
AVERAGE

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA AI/AP | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.06 | 0.84 | 4.03 | 3.19 | 3.79 | 0.22 | 3.11 | 14.63 | 11.51 |
| M1 | 0.02 | 0.41 | 0.75 | 0.34 | 0.82 | 0.10 | 1.70 | 3.08 | 1.38 |
| M2 | 0.34 | 2.03 | 4.43 | 2.41 | 1.19 | 1.38 | 8.26 | 17.92 | 9.65 |
| M3 | 0.00 | 0.23 | 1.69 | 1.46 | 6.46 | 0.00 | 0.57 | 4.27 | 3.70 |
| M4 | 0.18 | 1.30 | 6.41 | 5.11 | 3.92 | 0.47 | 3.46 | 17.39 | 13.93 |
| M5 | 0.03 | 0.59 | 1.83 | 1.24 | 2.10 | 0.11 | 2.13 | 6.59 | 4.46 |
| M6 | 0.11 | 1.01 | 5.79 | 4.78 | 4.75 | 0.32 | 2.95 | 17.34 | 14.39 |
| M7 | 0.04 | 0.52 | 1.02 | 0.50 | 0.97 | 0.12 | 1.59 | 3.09 | 1.51 |
| M8 | 0.15 | 0.84 | 1.62 | 0.78 | 0.92 | 0.54 | 3.06 | 5.85 | 2.79 |
| M9 | 0.00 | 0.57 | 1.62 | 1.06 | 1.87 | 0.00 | 2.79 | 8.07 | 5.27 |
| T0 | 0.03 | 0.48 | 1.28 | 0.80 | 1.67 | 0.12 | 1.78 | 4.69 | 2.91 |
| T1 | 0.06 | 0.51 | 1.24 | 0.72 | 1.41 | 0.22 | 1.80 | 4.37 | 2.56 |
| T2 | 0.34 | 1.73 | 4.61 | 2.89 | 1.67 | 0.95 | 4.78 | 12.49 | 7.71 |
| T3 | 0.20 | 0.95 | 2.16 | 1.21 | 1.27 | 0.57 | 2.63 | 5.92 | 3.29 |
| T4 | 1.08 | 3.40 | 4.96 | 1.55 | 0.46 | 3.99 | 12.60 | 18.33 | 5.73 |
| T5 | 0.35 | 1.39 | 2.69 | 1.30 | 0.93 | 1.11 | 4.46 | 8.59 | 4.13 |
| T6 | 1.14 | 3.64 | 5.34 | 1.69 | 0.46 | 3.70 | 11.88 | 17.44 | 5.56 |
| T7 | 0.02 | 0.42 | 0.77 | 0.36 | 0.86 | 0.08 | 1.70 | 3.17 | 1.46 |
| T8 | 0.01 | 0.51 | 0.98 | 0.46 | 0.90 | 0.05 | 2.25 | 4.29 | 2.04 |
| T9 | 0.03 | 0.73 | 1.11 | 0.37 | 0.51 | 0.16 | 3.69 | 5.57 | 1.88 |

AUGUST,89 Alkalinity Data
Std. Dev.

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA AI/AP | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| M0 | 0.074 | 0.798 | 2.030 | 1.288 | 5.556 | 0.280 | 3.089 | 7.994 | 5.083 |
| M1 | 0.027 | 0.168 | 0.143 | 0.122 | 0.598 | 0.110 | 0.702 | 0.587 | 0.472 |
| M2 | 0.246 | 1.133 | 1.647 | 0.867 | 4.939 | 1.028 | 4.792 | 6.472 | 3.001 |
| M3 | 0.000 | 0.074 | 0.479 | 0.431 | 2.708 | 0.000 | 0.184 | 1.204 | 1.087 |
| M4 | 0.353 | 1.517 | 2.906 | 1.513 | 7.035 | 0.932 | 3.975 | 7.082 | 3.321 |
| M5 | 0.052 | 0.636 | 1.363 | 0.786 | 2.588 | 0.185 | 2.301 | 5.013 | 2.929 |
| M6 | 0.205 | 0.925 | 1.753 | 1.148 | 36.026 | 0.577 | 2.587 | 4.922 | 3.439 |
| M7 | 0.041 | 0.317 | 0.420 | 0.174 | 1.128 | 0.127 | 1.019 | 1.391 | 0.563 |
| M8 | 0.207 | 0.928 | 1.271 | 0.378 | 1.140 | 0.760 | 3.429 | 4.714 | 1.401 |
| M9 | 0.000 | 0.620 | 1.083 | 0.575 | 1.055 | 0.000 | 2.957 | 5.087 | 2.681 |
| T0 | 0.042 | 0.301 | 0.429 | 0.512 | 2.521 | 0.155 | 1.167 | 1.589 | 1.835 |
| T1 | 0.062 | 0.326 | 0.643 | 0.436 | 0.289 | 0.219 | 1.161 | 2.377 | 1.607 |
| T2 | 0.361 | 1.279 | 1.783 | 0.922 | 3.674 | 0.999 | 3.614 | 5.168 | 2.428 |
| T3 | 0.237 | 0.783 | 1.118 | 0.376 | 1.592 | 0.671 | 2.252 | 3.308 | 1.136 |
| T4 | 0.592 | 1.096 | 1.005 | 0.469 | 0.336 | 2.154 | 3.969 | 3.548 | 1.672 |
| T5 | 0.278 | 0.543 | 1.202 | 1.197 | 1.215 | 0.873 | 1.677 | 3.670 | 3.725 |
| T6 | 0.650 | 1.234 | 1.387 | 0.316 | 0.137 | 2.025 | 3.724 | 4.084 | 0.961 |
| T7 | 0.020 | 0.184 | 0.300 | 0.125 | 0.264 | 0.082 | 0.755 | 1.240 | 0.523 |
| T8 | 0.018 | 0.223 | 0.264 | 0.143 | 0.646 | 0.082 | 0.977 | 1.186 | 0.672 |
| T9 | 0.049 | 0.151 | 0.133 | 0.080 | 0.186 | 0.259 | 0.715 | 0.635 | 0.436 |

JULY 1989
AVERAGE
FEED - SUBSTRATE

| SAMPLE | TS (%) | VS (%TS) | VS (%) | pH |
|---|---|---|---|---|
| F 2-20 | 20.46 | 96.42 | 19.73 | 4.69 |
| F 2-25 | 24.36 | 96.90 | 23.60 | 5.28 |
| F 2-30 | 30.49 | 97.20 | 29.63 | 4.62 |
| F 2-35 | 33.92 | 97.23 | 32.98 | 4.63 |
| F 2-40 | 38.81 | 97.23 | 37.73 | 4.64 |
| F 1-25 | 26.23 | 94.67 | 24.83 | 5.38 |
| F 1-30 | 29.74 | 94.75 | 28.18 | 5.53 |
| F 1-35 | 34.53 | 94.84 | 32.75 | 5.21 |
| F 1-40 | 39.96 | 95.06 | 37.99 | 5.18 |

JULY 1989
AVERAGE
FEED - SUBSTRATE

| SAMPLE | ALKAL. PHENOLPH. (mg/g MS) | ALKAL. PARTIAL (mg/g MS) | ALKAL. TOTAL (mg/g MS) | ALKAL. INTERM. (mg/g MS) | ALFA AI/AP | ALKAL. PHENOLPH. (mg/g TS) | ALKAL. PARTIAL (mg/g TS) | ALKAL. TOTAL (mg/g TS) | ALKAL. INTERM. (mg/g TS) |
|---|---|---|---|---|---|---|---|---|---|
| F 2-20 | 0.00 | 0.00 | 0.62 | 0.62 | * | 0.00 | 0.00 | 2.93 | 2.93 |
| F 2-25 | 0.00 | 0.00 | 0.37 | 0.37 | * | 0.00 | 0.00 | 1.48 | 1.48 |
| F 2-30 | 0.00 | 0.00 | 0.49 | 0.49 | * | 0.00 | 0.00 | 1.50 | 1.50 |
| F 2-35 | 0.00 | 0.00 | 0.62 | 0.62 | * | 0.00 | 0.00 | 1.81 | 1.81 |
| F 2-40 | 0.00 | 0.00 | 0.58 | 0.58 | * | 0.00 | 0.00 | 1.49 | 1.49 |
| F 1-25 | 0.00 | 0.00 | 0.80 | 0.80 | * | 0.00 | 0.00 | 2.87 | 2.87 |
| F 1-30 | 0.00 | 0.00 | 0.64 | 0.64 | * | 0.00 | 0.00 | 2.12 | 2.12 |
| F 1-35 | 0.00 | 0.00 | 0.73 | 0.73 | * | 0.00 | 0.00 | 2.10 | 2.10 |
| F 1-40 | 0.00 | 0.00 | 0.72 | 0.72 | * | 0.00 | 0.00 | 1.80 | 1.80 |

* does not exist