Final Report
On the Effect of
Macerating Toilets on Septic Tank Performance

Submitted to SFA Saniflo Inc.

Submitted by

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Table of Contents

List of Figures

List of Tables

Appendicies

1.0 Introduction

Conventional on-site wastewater systems treat wastewater using a combination of a septic tank and a soil absorption system. The septic tank provides anaerobic digestion of the raw sewage and also removes a significant portion of the solids by providing a quiescent zone for settling. Further treatment of the sewage is accomplished in the soil absorption system which is designed based on the expected performance of the septic tank and soil characteristics.

System failure can occur for a number of reasons, including higher than expected effluent strength leaving the septic tank. This can be caused by a variety of factors including excessive flows or higher than expected wastewater strength entering the tank, a poorly designed tank or an inadequately maintained tank.

In most conventional systems wastewater flows into the tank by gravity. In some cases, however, because of elevation requirements, some or all of the wastewater must be pumped from the house to the septic tank. In these instances, a macerating pump can be used as it reduces all solids to relatively small particles to facilitate pumping in small diameter pipes.

Although current research on the effects of macerating toilets on septic effluent appears to be limited, there are claims that macerating toilets increase the amount of total suspended solids in the septic tank effluent potentially leading to clogging of the soils in the soil absorption system. In some regions, codes and regulations put special requirements on the use of macerating toilets such as lower flow rates and larger septic tanks. For example, under the Title 5 Septic System regulations in Massachusetts, when a grinder pump is used prior to a septic tank, the discharge flow rate must be less than 20 gal/min (76 L/min) and the septic tank must have a minimum volume of 1,500 gallons (5,700L) as opposed to 60 gal/min (228 L/min) with a minimum tank size of 1,000 gallons (3,800 L) for non-grinder systems (Massachusetts Department of Environmental Protection, 1996). Another example is the Connecticut Public Health Code which recommends solids handling pumps over grinder pumps and requires an increase in septic tank capacity if greater than 25% of the flow will be pumped into the septic tank as it may cause sludge to be washed out of the tank into the bed (State of Connecticut, 2004).

SFA Saniflo Inc. is a major distributor of a plumbing system specifically designed for pumping into septic systems from lower elevations. A key component of the system (e.g, SaniPlus) is the use of a macerator pump. To help confirm and establish design parameters for their system, the effects of the use of their system on septic system performance are required.

In the Fall of 2003, the Ontario Rural Wastewater Centre (ORWC) was commissioned to undertake a study to determine the effect of using a macerating toilet on septic tank performance. Specifically, the ORWC was to look at water quality differences between septic tank effluent from systems that use macerating systems and septic tank effluent from systems which do not use macerators.

The ORWC commenced the Macerating Toilet Study in the Fall of 2003. The study took place over a period of six months under typical conditions and looked at septic tank effluent from ten systems with macerators and ten systems without macerators. This final report is to summarize the results of the study.

2.0 Objectives

The objective of this study was to determine whether there is a statistically significant difference between effluent coming from systems receiving wastewater from macerating toilets compared to those that only receive wastewater from conventional toilets operating under typical conditions.

3.0 Methodology

3.1 Site Selection

Twenty septic systems (ten households with macerating systems and ten households without macerating systems) were required for the project. The sample size (ten of each) was selected in order to be able to identify if the performance difference between the two sample sets was at least 10%, based on typical values of septic tank effluent quality and it's variability.

Macerating

To find households with macerating systems, a list of potential participants in the Guelph area was identified by Saniflo. These households included at least one macerating toilet and usually additional non-macerating toilets. Letters were written to potential participants explaining the nature of the study and to determine their suitability to participate in the study. As an incentive to participate in the study a free septic tank pump out was offered to selected participants.

Non-macerating

Systems without macerating pumps were identified by local septage haulers. These participants were given a letter explaining the nature of the study and asking them to participate.

3.2 Survey

As part of the assessment for each potential participant a letter was sent and survey conducted for owners of macerating and non-macerating systems. A copy of the letter and survey are included in Appendix A.

Macerating

To assess the suitability of potential participants with macerating systems, the survey was included in the initial letter. The purpose of the survey was to determine information regarding:

- House size (number of bedrooms, square footage, number of occupants),
- Number of toilets, and
- Frequency of use of macerating toilet.

Follow-ups to the letter and survey were conducted over the phone by ORWC staff. After receiving survey responses from potential participants with macerating toilets, households which didn't regularly use their macerating toilet systems were eliminated and suitable participants selected.

Non-Macerating

After being identified by local septage haulers, participants with non-macerating systems also filled out a survey to determine information regarding:

- House size (number of bedrooms, square footage, number of occupants), and
- Number of toilets.

3.3 Site Assessment

During the initial site visit, a visual site assessment of the septic tank characteristics and conditions was conducted. This included information on:

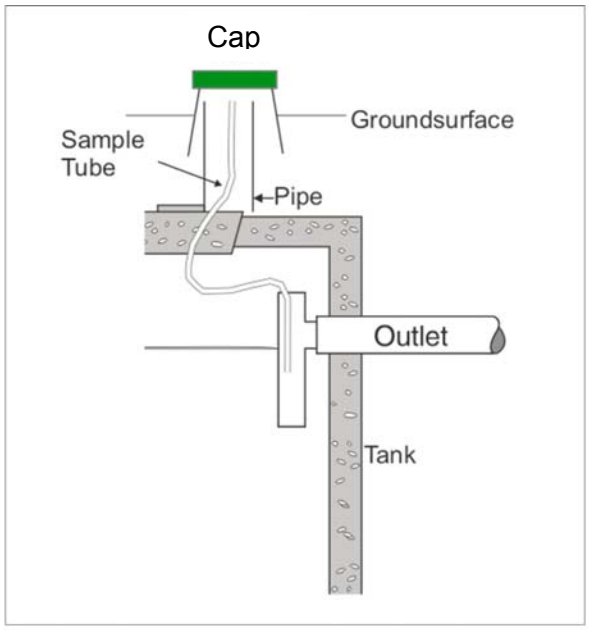
- Number of chambers,
- General condition of system,
- Visible signs of potential failures,
- Presence of effluent filter, and
- Other visual observations.

3.4 Monitoring

To facilitate monitoring over the period of the study, sampling capabilities were installed at each site. The objective of the sampling capability was to collect representative samples of the effluent which was leaving the system. Thus, the sampling occurred at the outlet of the tank, within the outlet tee. Apparatus consisted of a tube installed near the outlet of the tank and brought to the ground surface using 75mm diameter pipe which was then covered by an irrigation cap. Figure 1 illustrates the sampling set up.

Each sample was collected using a portable pump attached to the tube during each visit. To ensure a representative sample, prior to taking a sample for analysis, the pump was purged for several minutes to remove any build-up on or in the sample tube. Once collected, the sample was stored on ice until analysis.

Figure 1: Sampling Set Up



Initial visits to each location were conducted between late October and early December of 2003. During this visit, sampling equipment was installed and information recorded about the septic tank characteristics and conditions. Following the installation of sampling equipment, the first sample was collected and the systems were pumped out.

A second set of samples were collected two months after the first samples (between December 2003 and January 2004). The third and final sampling round was conducted during the first week of May 2004, approximately six months after the first sample. Sampling equipment was removed from each site following the collection of the third sample.

3.4 Analysis

All samples were collected as grab samples and analyzed for 5-day Biological Oxygen Demand (BOD_5) and Total Suspended Solids (TSS). These parameters were selected as they are most indicative of the potential for failure of the soil absorption system (Joy & Aaltomaa, 2002) and are 2 of the 3 parameters used in the Ontario Building Code (OBC) to indicate system performance.

All samples were analyzed by EnviroTest Laboratories, this lab is provincially accredited and located in Waterloo, Ontario. Samples were transported on ice to the lab and in most cases, analyzed within 24 hours. Standard methods of analysis were used for all samples.

4.0 Results

4.1 Survey and Assessment

All of the results obtained from the homeowner survey and assessment can be found in Appendix A.

From the survey it was determined that 2 to 6 residents lived in each household and there were 2 to 5 bedrooms in each household. For the macerating systems it was found that, in all but one household the macerating toilet was located in the basement and all macerating toilets were used more than 3 times a week. The macerating toilets had been installed between 1 and 10 years ago. The number of non-macerating toilets per household ranged from 1 to 4.

A summary of septic tank characteristics and conditions is presented in Table 1. In general, at the time of the field inspection, most systems appeared to be functioning properly. The most notable problem was overdue pump outs where 4 of the 20 systems were found to be overdue. It can also be noted that due to the age of the systems and changing code requirements, a few of the systems did not meet today's requirement of a two chamber tank (OBC, 1997).

Table 1: **Summary of Septic Tank Characteristics and Conditions**

Characteristic	Macerating Systems	Non-macerating Systems
Single Chamber Tanks	4	2
Pump out overdue	3	1
Damaged Tank	1 (cracked lid)	1 (damaged baffle)
Signs of Failure		1 (backflow)
Effluent Filter installed		2

4.2 Effluent Quality

Three rounds of effluent samples were collected at each location and analyzed for TSS and BOD_5. Round 1 was conducted prior to the tanks being pumped out, Round 2 was conducted two months following the pump out and Round 3 was conducted six months following the initial pump-out. A complete set of sample results for macerating and non-macerating systems are given in Appendix B and only summary and graphic results are presented here. As expected, results were variable due to the nature of different septic systems, nature of use, age and many other factors. The following sub-sections consider the two parameters separately.

4.2.1 Total Suspended Solids (TSS)

TSS concentrations for each location are presented below in Figures 2 (macerating) and 3 (non-macerating).

Figure 2: Macerating Systems - TSS

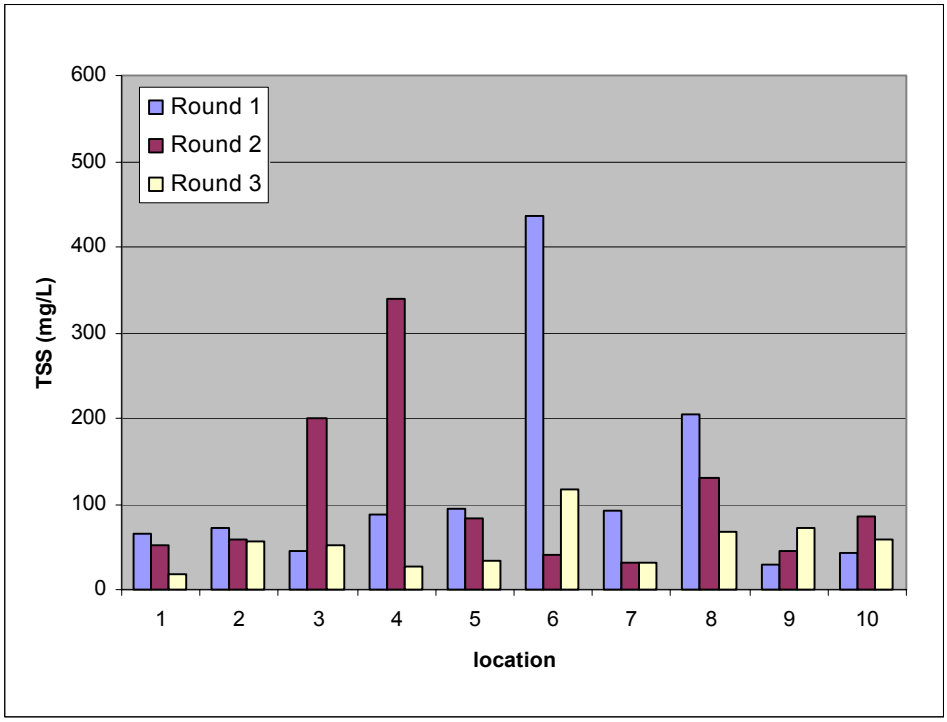
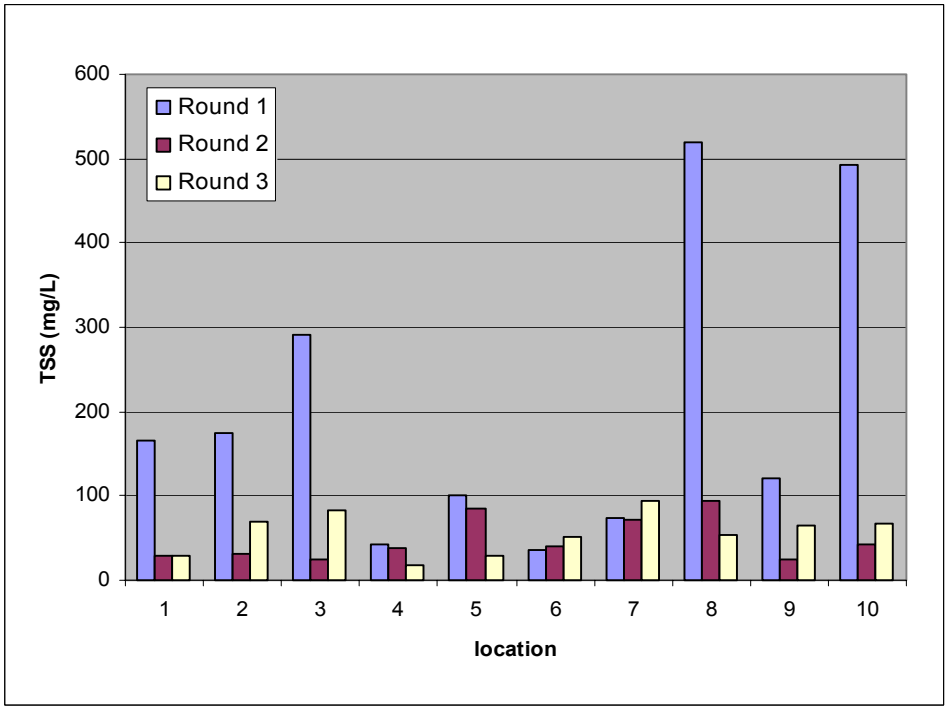


Figure 3: Non-Macerating Systems - TSS



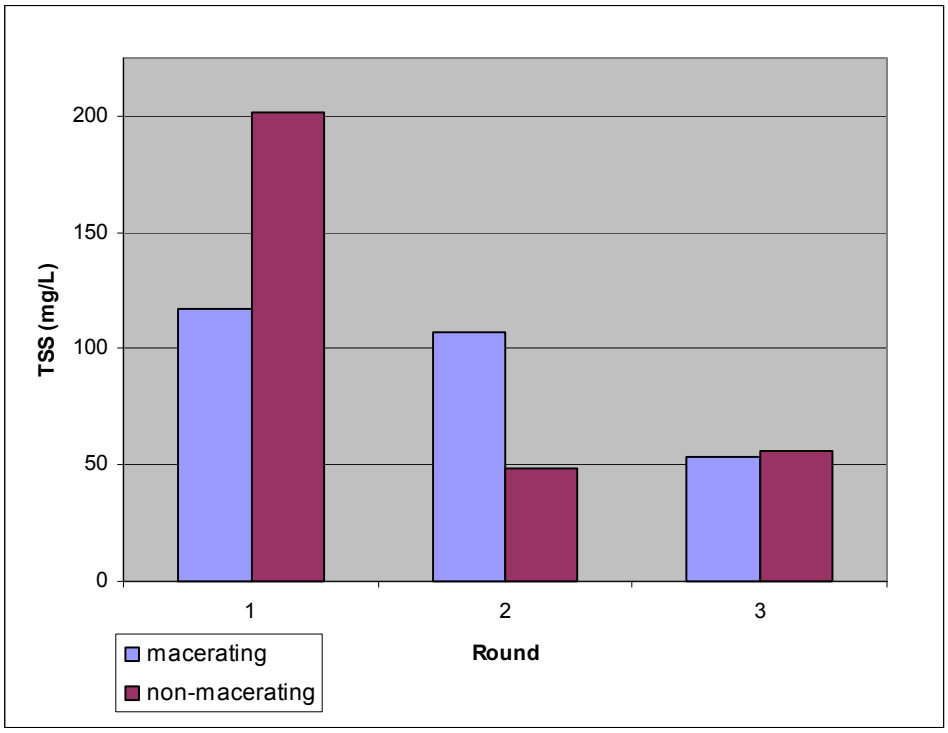
Averages from all three rounds of TSS samples fell within the typical range (40-140 mg/L), with the exception of Round 1 from the non-macerating systems which was higher than the typical range with a concentration of 202 mg/L. Average TSS concentrations for each round are summarized in Table 2. They are also presented graphically in Figure 4.

Table 2: Summary of Average TSS Concentrations

	Typical Range (mg/L)	Round 1 (mg/L)	Round 2 (mg/L)	Round 3 (mg/L)
Macerating	40-140	117	107	53
Non-Macerating	40-140	202	48	56

Note: Typical range is for residential septic tank effluent without a filter (Crites&Tchobanoglous, 1998)

Figure 4: Average TSS Concentrations By Sampling Round



A statistical analysis was performed on the data to determine if results from systems with macerating toilets and systems without macerating toilets were statistically different. The analysis was to answer the question: is the mean concentration of effluent with macerating toilet inputs statistically different from the mean concentration from systems without macerating toilet inputs, at a 95% confidence level? This assumes that the two samples are representative of the populations, i.e. they are representative of all systems, with and without macerating toilets.

A summary of results from the TSS statistical analysis is presented below in Table 3. For each round, all t values were within the critical t range and probability values were greater than the significance level (0.05) used. The results do not show a significant difference in TSS concentration between macerating and non-macerating systems for any of the sampling rounds.

Table 3: Summary of TSS Statistical Analysis

	Macerating	Non-Macerating	Macerating	Non-Macerating	Macerating	Non-Macerating
Round	1	1	2	2	3	3
Mean	117	202	107	48	53	56
Standard Deviation	122	177	96	26	76	24
t	1.2		-1.9		0.10	
$t_{critical\ (0.025)}$	-2.4 to 2.4		-2.4 to 2.4		-2.4 to 2.4	
Result	Not Sig. Different		Not Sig. Different		Not Sig. Different	

4.2.2 BOD_5

BOD_5 concentrations for each location are presented in Figures 5 (macerating) and 6 (non-macerating).

Figure 5: Macerating Systems - BOD_5

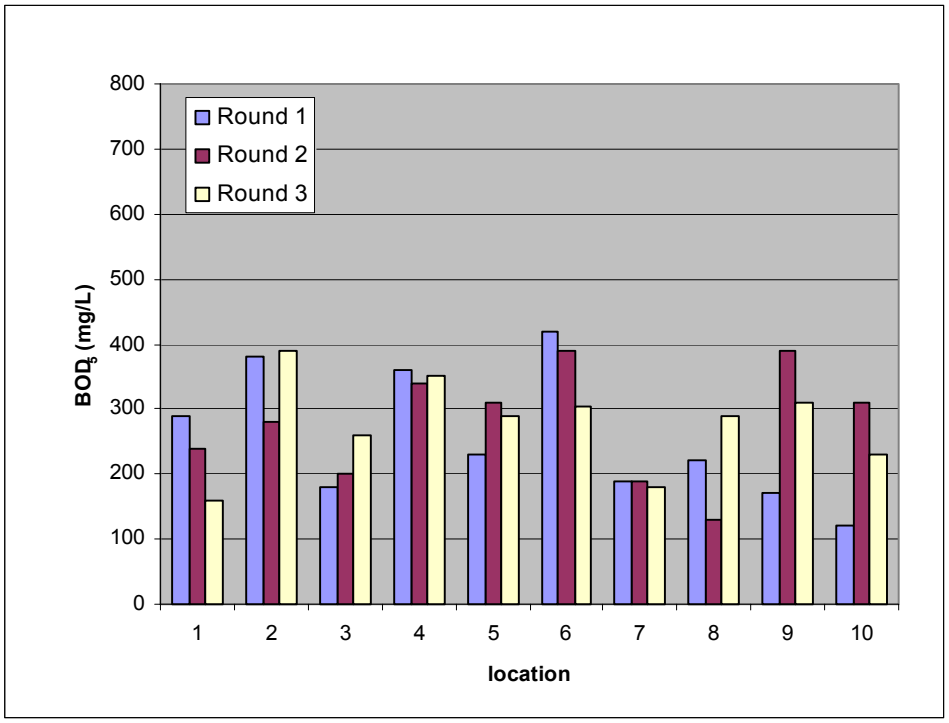
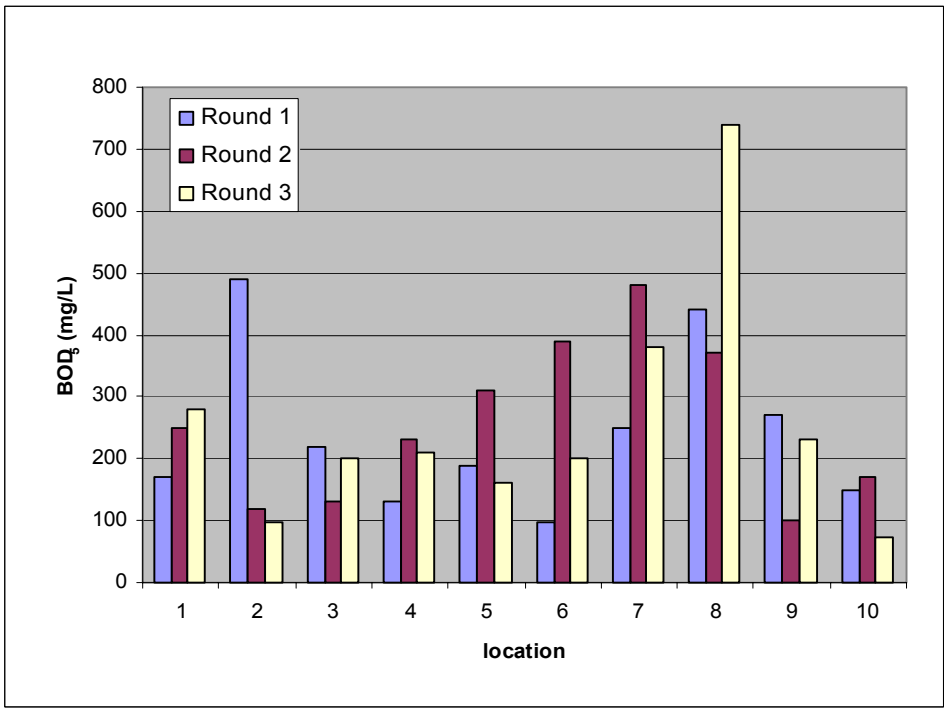


Figure 6: **Non-Macerating Systems - BOD_5**



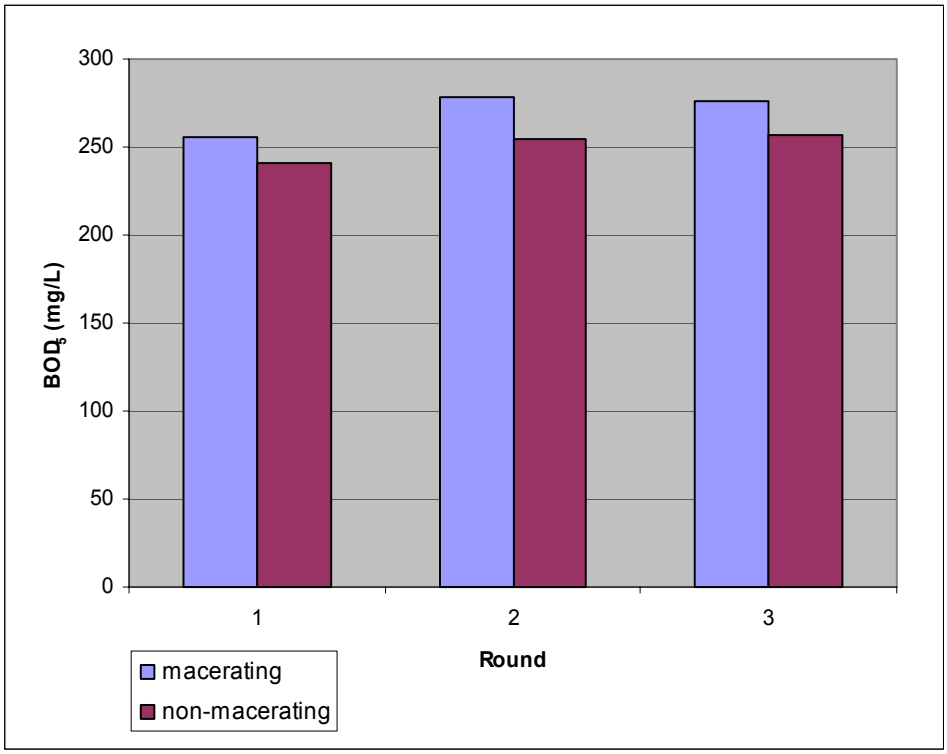
Averages from all three rounds of BOD_5 samples (macerating and non-macerating) were slightly above the published typical ranges (150-250 mg/L) with the exception of one non-macerating system average in Round 1 which was just within the range. Average BOD_5 concentrations for each round are summarized in Table 4. They are also presented graphically in Figure 7.

Table 4: **Summary of Average BOD_5 Concentrations**

	Typical Range (mg/L)	Round 1 (mg/L)	Round 2 (mg/L)	Round 3 (mg/L)
Macerating	150-250	256	276	273
Non-Macerating	150-250	240	255	257

Note: Typical range is for residential septic tank effluent without a filter (Crites&Tchobanoglous, 1998)

Figure 7: Average BOD_5 Concentrations By Sampling Round



An analysis similar to that conducted for TSS was conducted for BOD_5. A summary of results from the BOD_5 statistical analysis is presented below in Table 5. For each round, all t values were within the critical t range and probability values were greater than the significance level (0.05). The results do not show a significant difference in BOD_5 concentration between macerating and non-macerating systems.

Table 5: Summary of BOD_5 Statistical Analysis

	Macerating	Non-Macerating	Macerating	Non-Macerating	Macerating	Non-Macerating
Round	1	1	2	2	3	3
Mean	256	240	278	255	276	257
Standard Deviation	101	130	87	129	79	163
t	0.3		0.5		0.3	
$t_{critical\ (0.025)}$	-2.4 to 2.4		-2.4 to 2.4		-2.4 to 2.4	
Result	Not Sig. Different		Not Sig. Different		Not Sig. Different	

5.0 Discussion

Notable items from the study are discussed in the following section.

Since typical septic tank effluent has significant variations in constituent concentrations, the TSS and BOD_5 concentration ranges observed are considered to be normal for both sample sets (macerating and non-macerating).

There was no apparent relationship between the tank characteristics (noted during the initial assessment) and effluent quality for most systems in this study. These characteristics include the number of chambers, time since last pump out and tank condition. Although, it should be noted that the highest concentrations for TSS (520 mg/L, Round 1) and BOD_5 (740 mg/L, Round 3) observed throughout the entire study were from location #8 of the non-macerating systems. The rest of the TSS concentrations at this location were within the typical range and BOD_5 concentrations at this location were above the typical range. This system was identified as a single chamber system with considerable solids during the initial assessment, which may have contributed to the higher concentrations observed at this location.

In general, BOD_5 concentrations for macerating and non-macerating systems prior to pumping and following pumping were similar for all three rounds. This suggests that during this study, pumping did not have an impact on the BOD_5 concentrations.

Mean TSS concentrations for macerating and non-macerating systems were notably lower after the systems had been pumped (Rounds 2 and 3) suggesting that pumping reduced the amount of solids exiting the septic tanks.

Mean BOD_5 concentrations for macerating systems in all rounds were slightly higher (15 to 25 mg/L) than those for non-macerating systems. This difference is negligible considering the variations in septic effluent and is not statistically significant.

The difference in TSS concentrations for the macerating and non-macerating system sample sets were determined to not be significant for all sampling rounds. This suggests that septic effluent from macerating systems does not contain more TSS than septic effluent from non macerating systems.

Sampling took place at the exit of the tanks. It is possible, indeed likely, that at the entrance to the tanks, where sewage enters that the concentration would be different between systems using macerating toilets and those that do not use macerating toilets. However, the results show that whatever differences may exist at the entrance to the tank are ameliorated by the two to four day residency time in the tank before the effluent exits the tank.

In this study, only systems that use the SaniPro and SaniPlus systems of macerating toilets were used. These units have a maximum discharge rate of 36 L/minute. It is possible that systems with different macerating characteristics or higher flowrates may show different results.

6.0 Conclusions

A study of effluent from twenty septic tanks (10 macerating, 10 non-macerating) was carried out over six months to determine if septic tank effluent from macerating systems and non-macerating systems was significantly different. Field sampling and laboratory analysis were the means of assessment.

From analytical results collected during the study and a statistical analysis of the data, it can be concluded that the mean concentrations for TSS and BOD_5 between Saniflo macerating and non-macerating toilets are not significantly different for systems involved in this study. Systems which accept sewage from these macerating toilets do not contribute to higher septic tank effluent concentrations of TSS or BOD_5 when compared to systems which do not have macerating toilets.

References

Crites, R., Tchobanoglous, G., “Small and Decentralized Wastewater Management Systems”, McGraw-Hill, USA, 1998.

Joy, D. and Aaltomaa, T., “Field Testing of Absorption Bed Clogging”, paper presented at the Joint CSCE/ASCE Environmental Engineering Conf., Niagara Falls, ON, July, 2002.

Massachusetts Department of Environmental Protection. “State Environmental Code, Title 5: Standard Requirements for the Siting, Construction, Inspection, Upgrade and Expansion of On-Site Sewage Treatment and Disposal Systems and for the Transport and Disposal of Septage”. Massachusetts. 1996.

Ministry of Municipal Affairs and Housing, “Code and Guide for Sewage Systems 1997”, Toronto. Revised September 2003.

State of Connecticut, Department of Public Health, “Connecticut Public Health Code – Regulations and Technical Standards for Subsurface Sewage Disposal Systems”, Connecticut. Revised January 2004.

Appendix A

Homeowner Survey

October 21, 2003

Dear Homeowner,

The Ontario Rural Wastewater Centre (ORWC) is conducting a study on septic system effluent and would like your household to take part.

Participation in the research project will involve:

- Filling the attached survey
- Staff from the ORWC coming to take one effluent sample at the time of your next pump out and one sample two months later
- As a token of our appreciation, you will receive a small gift for your participation.

The Ontario Rural Wastewater Centre provides training, demonstration and applied research in the areas of residential on-site wastewater treatment, small community wastewater treatment as well as nutrient and agri-food wastewater management. The Centre researchers bring decades of applied research experience to bear on problems related to rural and unsewered wastewaters.

The project is scheduled to begin in October 2003. For more information on the centre or if you have any questions regarding the project, please contact Angela Mason at phone: 519.824.4120 x 54687, fax: 519.836.0227, email:anmason@uoguelph.ca.

I look forward to hearing from you,

Angela Mason BSc. Eng
Project Coordinator

September 29, 2003

Dear Homeowner,

The Ontario Rural Wastewater Centre is conducting a study on macerating toilets and your household has been identified as someone who has one.

In order to participate in the project, you will need to fill out the following survey:

- How many people live in the household? 1 2 3 4 other ___
- How many bedrooms are in your house? 1 2 3 4 other ___
- What is the square footage of your house? _____ ft^2
- Where is the macerating toilet located? Basement
  main floor
  upstairs
  other _____
- How frequently is your macerating toilet used? Once a day
  Greater than once a day
  Three times week
  Once a week
  Less than once a week

If you are selected:

- you will receive a FREE septic tank pump out ($300 value)
- Staff from the ORWC taking one sample at the time of pump out and one two months later

The Ontario Rural Wastewater Centre provides training, demonstration and applied research in the areas of residential on-site wastewater treatment, small community wastewater treatment as well as nutrient and agri-food wastewater management. The Centre researchers bring decades of applied research experience to bear on problems related to rural and unsewered wastewaters.

The project is scheduled to begin mid-October. If you are interested in participating, have any questions regarding the project or for more information on the centre, please contact Angela Mason at phone: 519.824.4120 x 54687, fax: 519.836.0227, email:anmason@uoguelph.ca.

I look forward to hearing from you,

Angela Mason BSc. Eng
Project Coordinator

Summary of Homeowner Survey Results

Macerating Toilet Study

Macerating Systems

	Town	Number of People Living in House	Number of Bedrooms	Square Footage	Location of Macerating Toilet(s)	Frequency of use	Type of toilet	Date Purchased
1	Elora	2	4	2950	2 on main floor	> once a day	Sanipro	1993
2	Acton	2	3	1100	basement	> once a day	Saniplus	17-Jun-03
3	New Hamburg	2	4	2200	basement	once a day	Saniplus	12-Apr-01
4	Tavistock	4	3	2400	basement	> once a day	Saniplus	1-Mar-03
5	Millbank1	2	3	1200	basement	3 times a week		
6	Millbank2	5	5	1800	basement	> once a day	Saniplus	9-Aug-00
7	Atwood	2	2	970	basement	3 times a week	Saniplus	1-Mar-02
8	St. Thomas	3	4	1600	basement	> once a day	Saniplus	1-Feb-00
9	Arthur	4	4	1475	basement	3 times a week	Saniplus	13-Oct-98
10	Grand Valley	4	2	1300	basement	> once a day	Saniplus	7-Dec-00

Non-Macerating Systems

	Town	Number of People Living in House	Number of Bedrooms	Square Footage	Number of Toilets
1	Guelph	4 +2 office employees	3	4000	4
2	Cambridge	6	4	1000	1
3	Roseville1	1	1	900	1
4	Roseville2	1	3	1100	1
5	Baden	4	3	2700	2
6	Everton	3	3	1860	3
7	Milverton1	3	3	1300	2
8	Milverton2	2	3	1000	2
9	Eden Mills	2	3	1250	2
10	Winterbourne	5	4	2400	3

Summary of Septic Tank Conditions

MaceratingToilet Study

Macerating Systems

	Location	*Septic Treatment Conditions*
1	Elora	dual chamber, obstructed outlet, last pumped 10+ years ago
2	Acton	35 year old dual chamber, regularly maintained
3	New Hamburg	single chamber, last pumped out 10 years ago
4	Tavistock	dual chamber, pumping overdue
5	Millbank1	single chamber, last pumped 1 or 2 years ago
6	Millbank2	single chamber, installed in 1989
7	Atwood	single chamber, last pumped 2 or 3 years ago
8	St. Thomas	dual chamber, last pumped 3 years ago, floating solids
9	Arthur	dual chamber, in good shape
10	Grand Valley	dual chamber, lid cracked, new tank to be installed

Non-Macerating Systems

	Location	*Septic Treatment Conditions*
1	Guelph	dual chamber, considerable top crust, effluent filter installed
2	Cambridge	dual chamber, outlet baffle damaged, last pumped 4 or 5 years
3	Roseville1	dual chamber, minimal solids
4	Roseville2	single chamber, regularly maintained
5	Baden	dual chamber, in good shape, effluent filter installed
6	Everton	dual chamber, last pumped 4 or 5 years ago, minimal solids
7	Milverton1	dual chamber, backflow from outlet and inlet, due for new?
8	Milverton2	single chamber, considerable solids, sample water was black
9	Eden Mills	single chamber, last pumped 4 years ago due for pump out
10	Winterbourne	single chamber, last pumped 5 years ago, due for pump out

Appendix B
Analytical Results

Summary of Sample Results

Macerating Toilet Study

Macerating

	Location	Round1 (mg/L) BOD	Round1 (mg/L) TSS	Round 2 (mg/L) BOD	Round 2 (mg/L) TSS	Round 3 (mg/L) BOD	Round 3 (mg/L) TSS
1	Elora	290	66	240	52	160	17
2	Acton	380	72	280	58	390	55.5
3	New Hamburg	180	46	200 *	200	260	51
4	Tavistock	360	88	340 *	340	350	28
5	Millbank1	230	95	310	84	290	34
6	Millbank2	420	435	390	41.3	304	116
7	Atwood	190	92	190	32	180	32
8	St. Thomas	220	205	130	130	290	67
9	Arthur	170	30	390	46	310	73
10	Grand Valley	120	43.3	310	86	230	58

Notes: * - Result is for CBOD.

Non-Macerating

	Location	Round1 (mg/L) BOD	Round1 (mg/L) TSS	Round 2 (mg/L) BOD	Round 2 (mg/L) TSS	Round 3 (mg/L) BOD	Round 3 (mg/L) TSS
1	Guelph	170	165	250	30	280	30
2	Cambridge	490	175	120	32	98	70
3	Roseville1	220	290	130	24	200	83
4	Roseville2	130	43.3	230	38	210	19
5	Baden	190	100	310	84	160	30
6	Everton	98	36.7	390	41.3	200	51
7	Milverton1	250	74	480	72.5	380	95
8	Milverton2	440	520	370	94	740	53
9	Winterborne	270	120	100	24	230	64
10	Eden Mills	150	493	170	42	73	68