Industry allocated project number	PHI allocated project number

SATI tarryn@satgi.co.za Tel: 021 863-0366	CFPA inmaak@mweb.co.za Tel: 021 872-1501	SAAPPA/SASPA theresa@hortgro.co.za Tel: 021 882-8470	DFTS dappies@dtd.co.za Tel: 021 870 2900	Winetech andraga@winetech.co.za Tel: 021 276 0499

Indicate (X) client(s) to whom this concept project proposal is submitted. Replace any of these with other relevant clients if required.

NB: The instructions in red, throughout the template, should be omitted from the final document.

FINAL REPORT
2016

1. PROGRAMME AND PROJECT LEADER INFORMATION

	Research Organisation Programme leader	Research Team Manager	Project leader
Title, initials, surname	Prof GO Sigge		same
Present position	Ass. Prof & HoD		same
Address	Department of Food Science Stellenbosch University Private Bag X1, Matieland, 7602		same
Tel. / Cell no.	(021) 808 3581		same
Fax	(021) 808 3510		same
E-mail	gos@sun.ac.za		same
	Co-worker	**Student**	
Title, initials, surname			
Present position			
Address			
Tel. / Cell no.			
Fax			
E-mail			

2. PROJECT INFORMATION

Research Organisation Project number	2013_27
Project title	Anaerobic sequencing batch reactor (AnSBR) technology to treat winery wastewater
Short title	Anaerobic sequencing batch reactor (AnSBR) technology to treat winery wastewater

Fruit kind(s)	N/A		
Start date (mm/yyyy)	01/01/2013	**End date** (mm/yyyy)	31/12/2015

Key words	Anaerobic sequencing batch reactor, winery wastewater

Approved by Research Organisation Programme leader (tick box) ☐

Version 2015

THIS REPORT MUST INCLUDE INFORMATION FROM THE **ENTIRE** PROJECT

3. EXECUTIVE SUMMARY

The overall objective of this study was to investigate the principles and kinetics of the AnSBR process so that optimum design and operational parameters for efficient and stable treatment can be determined. The main objective was to acquire data that could be used to generate prediction models of the anaerobic digestion of winery wastewater processes and subsequently enable predictions to be made as to the treatability of the winery wastewater by AnSBR.

Two different approaches were followed. The first involved monitoring certain parameters, such as COD, pH, conductivity, temperature, Oxidation-Reduction Potential (ORP) and gas production throughout the digestion cycle so as to use these values in the ADM 1. The second approach involved using a statistical central composite design to determine the effect of pH, feeding regime and mixing rate on the performance of the AnSBR, by monitoring COD reduction, influent and effluent pH, volatile fatty acids, alkalinity, polyphenol reduction, temperature and the VFA: alkalinity ratio.

Approach 1:
It was found that the AnSBR can operate solely on pH control while operating on a Volumetric Discharge Fraction (VDF) of 0.5 with the feed pH at 4.29 and have the COD made up of 92% monosaccharides. This was found to be true while operating the AnSBR with OLRs between 1.1 and 3.1 gCOD.L^{-1}.d^{-1}. A COD reduction in excess of 80% was obtained between OLRs of 1.1 and 2.1 gCOD.L^{-1}.d^{-1} which legally allows up to 50 m^{3}.d^{-1} of treated wastewater to be disposed via irrigation.

A biogas containing methane, carbon dioxide and nitrogen was produced. When the nitrogen was excluded, the methane fraction formed more than 80% of the biogas. This means that the calorific value of the biogas increased by 5.32 MJ/m$_3$ compared to the typical biogas production which is made up of 70% methane and 30% carbon dioxide.
The modelling of the ASBR with the use of the ADM1 was only partially successful in this study. Problems occurred with modelling sludge retention and the biogas production rate with the differential solver method used.

It is thus clear that using the ADM1 model, is at this stage not a feasible option to sufficiently predict the potential of a winery wastewater treatment process by making using of AnSBR technology.

Approach 2:
The main objective of this approach was to investigate the feasibility of the AnSBR to specifically treat synthetic winery wastewater and to optimise the operational parameters that affect the efficiency of the process by making use of a central composite design. The study was sub-divided into different Experimental Phases (A – D). The aim of Phase A and C was to investigate the feasibility of the novel AnSBR (14.7 L) to treat a synthetic winery wastewater substrate at COD's ranging from 1 000 – 7 000 mg.L^{-1}. At a COD of 4 000 mg.L^{-1} (Phase A) a 88% COD reduction occurred, the alkalinity was approximately at 3 000 mgCaCO$_3$.L^{-1}, the total Volatile Fatty Acid (VFA) concentration at 125 mg.L^{-1} and the pH was effectively controlled at *ca*. 7.2 by the 2 M KOH chemical dosing system. At a COD of 7 000 mg.L^{-1} (Phase C) an 80% COD reduction occurred, the alkalinity was approximately at 3 000 mgCaCO$_3$.L^{-1}, the total VFA's = 500 mg.L^{-1} and the pH was effectively controlled at *ca*. 7.2. A central composite experimental design (CCD) was used to optimise three independent parameters at a five-level design at COD = 4 000 mg.L^{-1} (Phase B) and COD = 7 000 mg.L^{-1} (Phase D). The parameters investigated were: X_1 = pH; X_2 = feeding time (shorter feeding time (batch process) vs. longer

feeding time (fed-batch process)) and X_3 = mixing frequency (mixing set for 10 s every X_3 min). The data was used to fit a regression coefficient model from which response surface methodology (RSM) plots were drawn to indicate an interaction effect with regard to a specific efficiency measurement. The optimisation of the three parameters was measured according to these efficiency measurements: 1) COD reduction; 2) Total Suspended Solids (TSS) content of the effluent; 3) VFA:Alkalinity ratio; 4) Methane percentage; and 5) Polyphenol reduction percentage. The results of Phases A and C showed that the AnSBR was capable of efficiently treating SWW at COD's up to 7 000 $mg.L^{-1}$. The optimisation studies (Phase B and D) showed that the optimal operational conditions at an influent COD = 4 000 $mg.L^{-1}$ and 7 000 $mg.L^{-1}$, would be an influent pH of *ca.* 6.7 – 7.3 (pH = 7.3), a longer feeding time (possibly 240 min) and a less frequent mixing (10 s every *ca*. 110 min).

The validation of the optimal values obtained during Experimental Study Phase B & D of Approach 2 (Central Composite Design) should be applied to a full-scale AnSBR. Therefore, further research should be conducted on a pilot scale set-up to perform the same type of optimisation research, followed by a validation experiment. It is recommended that the AnSBR process be up-scaled into a pilot scale set-up to optimise the operational parameters before up scaling the process to an industrial scale. This should be done to determine the feasibility and the cost of the process on a larger scale.

4. PROBLEM IDENTIFICATION AND OBJECTIVES

Problem being addressed and ultimate aim of the project

By the year 2030 South Africa's water demand will overtake the water supply, but shortages already exist on a regional basis and, therefore, proposals have been made to encourage re-use of factory effluents. The wine industry, which uses large amounts of water, is thus faced with two major problems. Firstly, maintaining a profitable level of production while reducing the intake of fresh, potable water, and secondly, disposing of, or re-using a portion of the large volumes of effluent in an environmentally friendly manner.
The objective of this study would be to investigate the use of anaerobic sequencing batch reactor (AnSBR) technology to treat winery wastewater by utilising the Anaerobic Digestion Model 1, thereby determining the optimum operational parameters for efficient treatment.

Milestones and date expected that these milestones be reached

1. Design and construct two lab-scale anaerobic sequencing batch reactors – 31 July 2013;
2. Testing and commissioning of reactor configuration and control systems - 30 November 2013;
3. Extend software to an AnSBR configuration (completely mixed batch reactor) – 30 November 2014;
4. Parameter tuning and optimisation of model – 30 November 2014;
5. Model validation by experimental trials – 30 November 2015.

5. WORKPLAN (MATERIALS AND METHODS)

Phase 1: Design and construct two lab-scale anaerobic sequencing batch reactors

Actions:

- Design reactor to simulate an up-scalable process;
- Design control systems for temperature, mixing, measurement of gas production, pH control, decanting and filling.

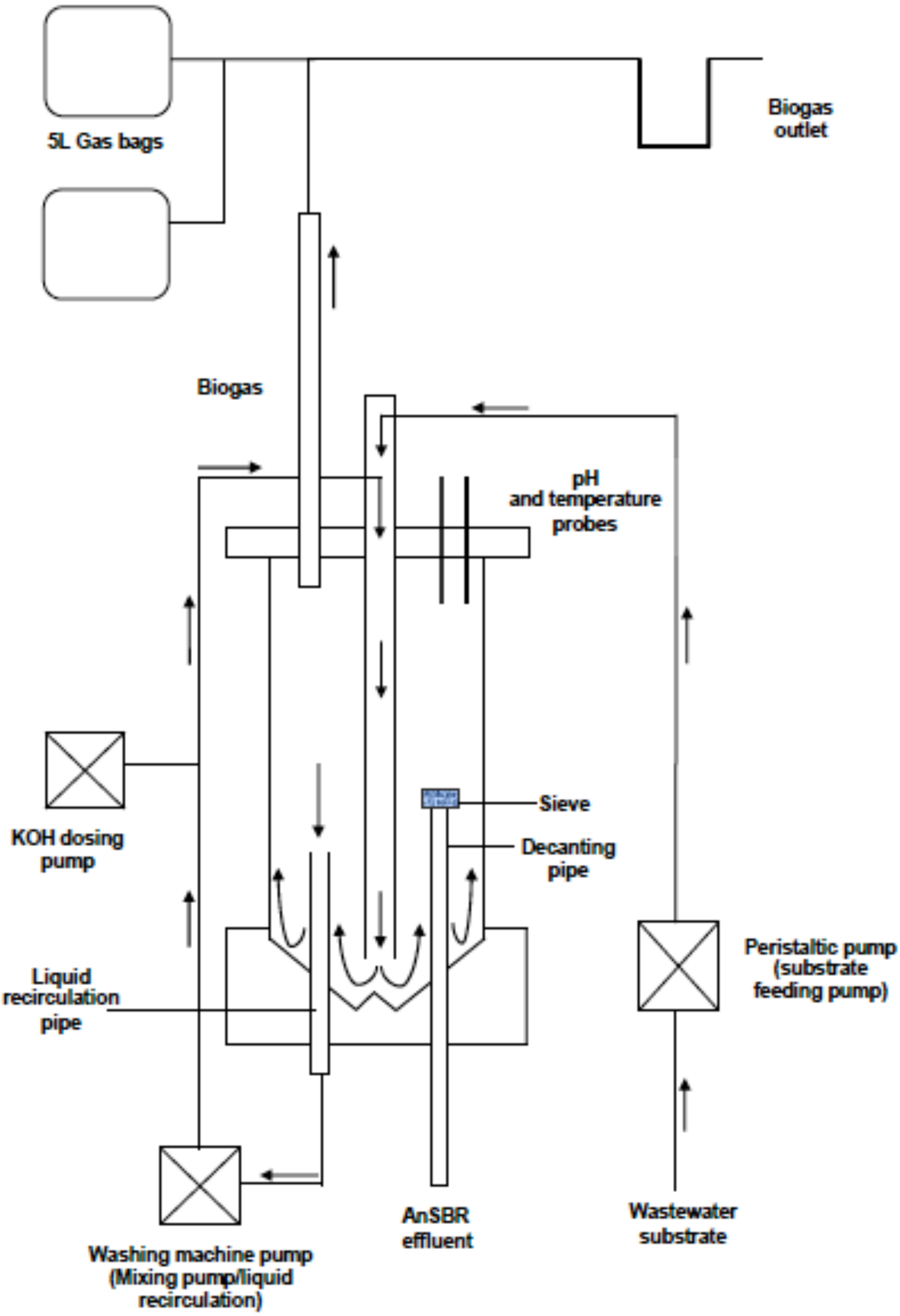

Figure 1. Diagram of the laboratory-scale Anaerobic Sequencing Batch Reactor (AnSBR)

Phase 2: Testing and commissioning of reactor configuration and control systems

Actions:
- Commision reactors;
- Test control systems for temperature, mixing, measurement of gas production, pH control, decanting and filling.

Phase 3: Extend software to an AnSBR configuration (completely mixed batch reactor)

Actions:
- Implement ADM 1 into a MatLab or AquaSim or similar software package ;
- Extend the model to the specific substrate including degradation mechanisms for ethanol and phenolics;
- Verification of model and implementation using published data sets.

Phase 4: Parameter tuning and optimisation of model

Actions:
- Develop and verify kinetic coefficients & physico chemical equilibrium from experimental data.

Efficiency parameters measured will include:
- Chemical oxygen demand (COD);
- Biogas production
- Alkalinity;
- Total suspended solids (TSS);
- Volatile suspended solids (VSS);
- Volatile fatty acids (VFA's).

Output -> degradation rate equations

Phase 5: Model validation by experimental trials

Actions:
- The model will be validated by experimental trials in the AnSBR's to verify reaction kinetics to determine the influence of the following on treatment efficiency and reactor stability:
    - Organic loading rate (OLR);
    - Hydraulic retention time (HRT);
    - Cycle times (duration/rate of feed, react, settle, decant);
    - pH;
    - Temperature.

6. RESULTS AND DISCUSSION

Two different approaches were followed. The first involved monitoring certain parameters, such as COD, pH, conductivity, temperature, Oxidation-Reduction Potential (ORP) and gas production throughout the digestion cycle so as to use these values in the ADM 1. The second approach involved using a statistical central composite design to determine the effect of pH, feeding regime and mixing rate on the performance of the AnSBR, by monitoring COD reduction, influent and effluent pH, volatile fatty acids, alkalinity, polyphenol reduction, temperature and the VFA: alkalinity ratio.

Approach 1:
With the study, two main objectives had to be achieved. The first was to determine whether a AnSBR can operate on pH control and the second being to determine if the ADM1 can be used for AnSBR simulation.

It was found that the AnSBR can operate solely on pH control while operating on a VDF of 0.5 while the feed pH is at 4.29 and have the COD made up of 92% monosaccharides. This is true while operating the AnSBR with OLRs between 1.1 and 3.1 gCOD.L^{-1}.d^{-1} and only having 15% of the AnSBR filled with sludge. Furthermore, reducing the VDF should allow the AnSBR to still function under this setup.

With the current ASBR setup, ammonium sulphate concentrations of 5000 mg.L^{-1} within winery wastewater can be treated between OLR of 1.1 and 1.8 gCOD.L^{-1}.d^{-1} while achieving a COD reduction of at least 65%. Under conditions where the feed substrate contains no ammonium sulphate, a COD reduction in excess of 80% can be obtained between OLRs of 1.1 and 2.1 gCOD.L^{-1}.d^{-1}. A factor of 0.035 mgKOH.L^{-1}.mgCOD^{-1} removed can be used to determine the requirements for KOH dosing while the AnSBR is operated between OLRs of 1.1 and 3.1 gCOD.L^{-1}.d^{-1}.

Under the experimental operating conditions, an OLR of 1.9 gCOD.L^{-1}.d^{-1} produces the most biogas and highest methane yield of 0.16 L.gCOD^{-1} removed when feeding at a pH of 4.29. The biogas produced with the AnSBR contained nitrogen. If the nitrogen were to be removed by feeding at a higher COD:N ratio, an upgraded biogas can be formed. Within this study approach, methane made up more than 80% of the biogas, which meant a HHV increase of 5.32 MJ/m3 over the typical biogas production of 70% methane and 30% carbon dioxide.

Approach 2:
Therefore, the main goal of this approach was to investigate the feasibility of a novel designed AnSBR to treat a synthetic winery wastewater substrate and to optimise the operational parameters that affect the performance of the AnSBR. The aims of this approach were achieved by sub-dividing the study into different phases (Experimental Phases A – D). The first aim required the investigation of the feasibility of the AnSBR to be able to treat a synthetic winery wastewater substrate. This aim was investigated at a lower COD concentration (ranging from 1 000 – 4 000 mg.L^{-1}) of the synthetic winery wastewater substrate (Phase A). The aim of investigating the feasibility of the AnSBR to treat synthetic winery wastewater was also applied at a higher COD concentration (ranging from 4 000 – 7 000 mg.L^{-1}) identified as Experimental study Phase C. The second aim was to optimise the operational parameters that affects the performance of the AnSBR. The optimisation of parameters were applied at a lower COD concentration of 4 000 mg.L^{-1} (Phase B) and at a higher COD concentration of 7 000 mg.L^{-1} (Phase D). The following parameters were aimed to be optimised: X_1 = pH; X_2 = feeding time (shorter feeding time (batch process) vs. longer feeding time (fed-batch process)) and X_3 = mixing frequency (mixing set for 10 s every X_3 min).

Within the research done in this study a novel designed laboratory-scale AnSBR was used with a working volume of 13.2 L. The AnSBR contained granular mesophilic biomass which was kept at 35°C. The AnSBR requires four distinct steps during each cycle (feeding, reacting, settlement and decanting). Each cycle was approximately 24 h resulting in a HRT of 1.65 days. The OLR was increased step-wised from 0.60 – 4.23 kgCOD.m^{-3}.d^{-1}.

Phase A & C: Investigating the feasibility
The aim of Phase A & C was to investigate the feasibility of the anaerobic digestion process at an increasing COD concentration ranging from 1 000 – 4 000 mg.L^{-1} for Phase A and 4 000 – 7 000 mg.L^{-1} during Phase C. The results indicated that pH control is a very important parameter to manage. When the automated chemical dosing (2 M KOH) did not occur within the AnSBR for a few cycles the efficiency measurements were unstable (due to the broken pH probe inside

the AnSBR). The COD reduction decreased (average of 65%), the alkalinity decreased (a low of 1 325 $mgCaCO_3.L^{-1}$), the VFA increased (a high of 700 $mg.L^{-1}$) and pH of the effluent decreased. The results also indicated that the biomass could be prone to inhibition due to the unwanted chemicals within the substrate. Therefore, it is recommended that the necessary characterisation should be done on the substrate before feeding to an anaerobic digestion bioreactor. It was possible that ammonium and sulphate inhibition occurred during Phase A. The substrate contained high amounts of ammonium sulphate added to the substrate according to the chemical composition of synthetic winery wastewater as used by Malandra *et al*. (2003). The latex pipes connected to the AnSBR in this study were perished, possibly due to the hydrogen sulphide gas formation. Inhibition could have occurred resulting in the possibility of the sulphur reducing bacteria (SRB) being activated, and thus competing with the methanogenic bacteria for substrates. However, currently ammonium sulphate is not being used in the wine industry, only potassium sulphate as a supplement for the yeast during the wine making process and only in small amounts (Rossouw, J., 2015, Environmental Manager, Distell, Stellenbosch, South Africa, personal communication, 11 May). When the chemical characteristics of the substrate were altered the efficiency measurements were stable again.

Overall, for Phase A and C stable efficiency measurements were obtained, therefore concluding the feasibility of the process. For Phase A an average COD reduction of 77% occurred, the alkalinity gradually increased from 500 – 3 000 $mgCaCO_3.L^{-1}$, an average of 170 $mg.L^{-1}$ VFA was obtained and the pH was efficiently controlled. For Phase C stable efficiency measurements were also obtained, treating a COD concentration range between 4 000 – 7 000 $mg.L^{-1}$ an average COD reduction of 77% was achieved, the alkalinity was at an average of 2 300 $mgCaCO_3.L^{-1}$, the total VFA concentration was at an average of 300 $mg.L^{-1}$ and the pH was efficiently controlled. However, at a higher COD concentration of 7 000 $mg.L^{-1}$ a higher VFA concentration of approximately 500 $mg.L^{-1}$ was reached. The average VFA concentrations obtained during Phase D (at a constant COD concentration of 7 000 $mg.L^{-1}$) were approximately 900 $mg.L^{-1}$. The VFA were higher than for Phase A indicating a slight incompletion of the anaerobic digestion process, or the insufficient conversion of the intermediate products to the end product. It could be recommended that higher VFA concentrations at a high COD substrate concentration could be lowered by increasing the 24 h cycle length of the process to ensure a more complete anaerobic digestion of the substrates.

Phase B & D: Optimisation of operational parameters

The aim of Phase B & D was to optimise the operational parameters that affect the performance of the AnSBR at a constant COD concentration of 4 000 $mg.L^{-1}$ (Phase B) and at 7 000 $mg.L^{-1}$ (Phase D). For the purpose of optimisation a central composite experimental design (CCD) was used which enabled the optimisation of three independent parameters at a five-level experimental design. The minimum and maximum values were chosen within this five-level design, whereas the absolute minimum, centre point and absolute maximum values were calculated according to the CCD. The study required 16 cycles done in a randomised order in duplicate (each cycle had its own set of combined operational parameters values). The separate data (Phase B and D) obtained during the CCD was used to fit into the regression coefficient model from which response surface methodology (RSM) plots were drawn to indicate an interaction effect with regard to a specific efficiency measurement. The optimisation of the three parameters was measured according to these efficiency measurements: 1) COD reduction; 2) TSS content of the effluent; 3) VFA:Alkalinity ratio; 4) Methane percentage and 5) Polyphenol reduction percentage. The predominant optimal values for both Experimental study Phase B and D were found to be: X_1 = pH of 7.3; X_2 = feeding time of 4 h with regard to a 24 h cycle and X_3 = 10 s mixing every 110 min. The last cycle during the first set of 16 cycles (Phase B) was seen to be detrimental to the granular biomass. The mixing frequency of 10 s mixing every 9.5 min resulted in the granules shearing, causing extensive biomass washout. Therefore, it is recommended that a different absolute minimum value for the mixing frequency of at least every 20 min should be used instead of every 9.5 min.

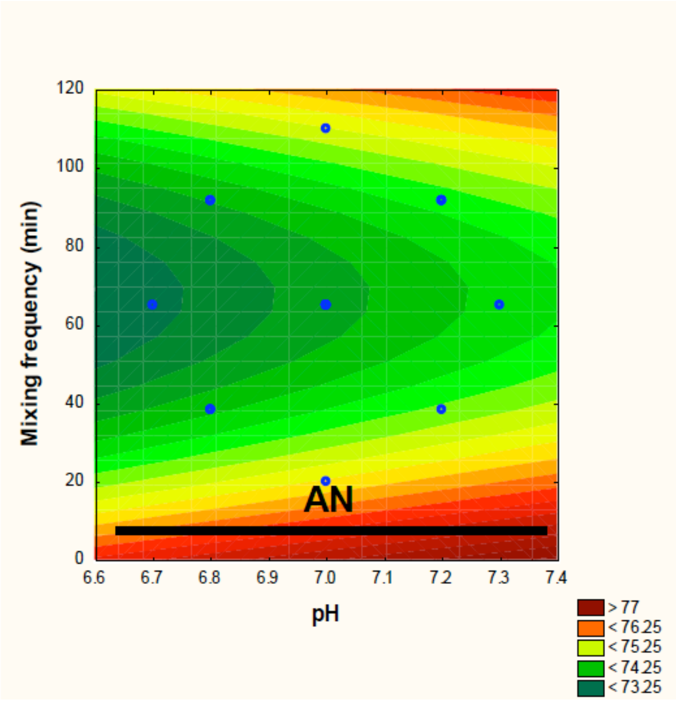

Figure 1. RSM contour plot of the COD reduction response with regard to the interaction between the mixing frequency and pH. AN indicates the region where a high COD reduction was observed (i.e. at any pH combined with a more frequent mixing).

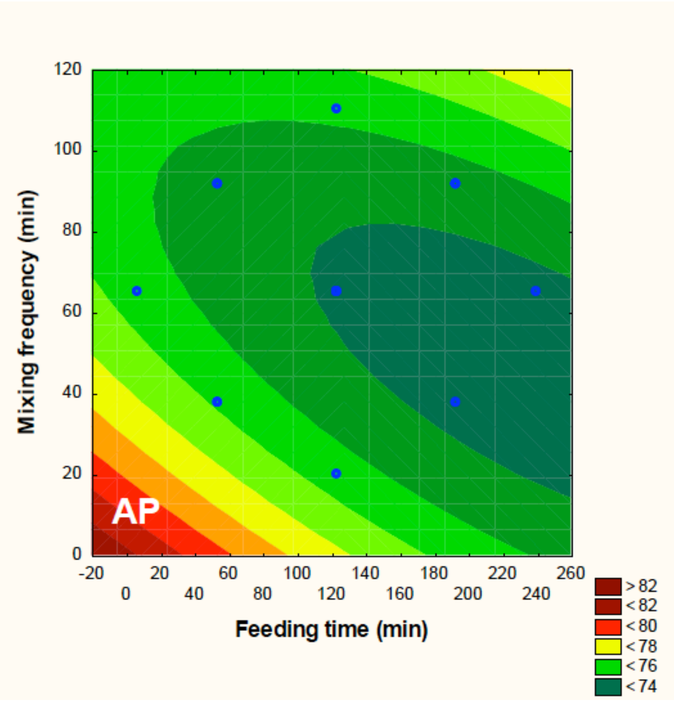

Figure 2. RSM contour plot of the COD reduction response with regard to the interaction between the mixing frequency and feeding time. AP indicates the region where a high COD reduction was achieved (i.e. at a shorter feeding and more frequent mixing).

7. COMPLETE THE FOLLOWING TABLE

Milestone	Target Date	Extension Date	Date completed	Achievement
1. Design and construct two lab-scale anaerobic sequencing batch reactors	31 July 2013		31 July 2013	Two laboratory-scale AnSBR's were designed and constructed and use din the subsequent approaches to treatment of synthetic winery wastewater.
2. Testing and commissioning of reactor configuration and control systems	30 November 2013		30 November 2013	Testing and commissioning was adapted and optimised form the initial design to the final configurations.
3. Extend Anaerobic Digestion (AD) Model/software to an AnSBR configuration (completely mixed batch reactor)	30 November 2014		30 November 2014	The ADM 1 model was extended to the MatLab software, and data generated was inputted into the model for adaptation.
4. Parameter tuning and optimisation of AD model	30 November 2014		30 November 2014	Parameter tuning and optimisation of the AD model were done by two different approaches.
5. AD Model validation by experimental trials	30 November 2015		30 November 2015	Validation of the models and the feasibility of AnSBR technology to treat synthetic winery wastewater was done using two approaches
6.Journal publication (s) – final milestone				

8. CONCLUSIONS

Approach 1:
It is recommended that the intermediate and partial alkalinity is also measured. They help provide an indicator for the performance of the AnSBR with regards to the sludge. If the partial alkalinity were to suddenly increase, it indicates an accumulation of VFAs. When the partial alkalinity decreases, it indicates that less bicarbonate is being produced, consequently indicating that the methanogens are less active as less carbon dioxide is being formed.
With regards to pH control, it is recommended to increase the feed substrates pH to 7.43 so that a higher COD reduction and more biogas can be produced. Secondly, the dosing setup of the pH controller needs to be changed to reduce the pH dip in the first 3 h of the batch. This can be achieved by dosing earlier in the process, however, it must be such that it does not go beyond 7.4 or inhibition can occur. A further recommendation in terms of equipment is to pre-heat the feed substrate into the AnSBR. This could help with reducing methanogens inhibition in the early stages of the treated batch.

ADM1 simulation for an ASBR
The modelling of the ASBR with the use of the ADM1 was only partially successful in this study. Problems were found with modelling sludge retention and biogas production leaving the system. The normal ADM1 model does not incorporate sludge retention into its mass balance differentials. To overcome this, the sludge retention was modelled as if the sludge was separated with a clarifier and returned to the AnSBR. However, the modelling of this showed that the decant phase cannot be too short or else it won't model sludge retention successfully. Further work needs to be done here so that the ADM1 can simulate an AnSBR with the use of an ordinary differential solver instead of using a more processing intense constant time step.

For the biogas production rate, the model would either over predict or predict negative gas production due to unstable conditions in the AnSBR. The biogas production rate is dependent on the partial pressures of the gases which in turn are dependent on the transfer rate from the liquid phase. This transfer rate is further dependent on the concentration of that specific gas in the liquid phase. However, the biggest problem occured when the transfer was made to the partial pressure of the biogas and the subsequent biogas production rate. This is an area where the model needs more work.

Another problem with the model, is the stability. When poorly selected soluble and particulate concentrations are specified, the model can become unstable. It seemed that when the sludge concentrations are not known, over specifying the sludge concentration and greatly under specifying the initial soluble concentrations of the AnSBR, helped the most with regards to simulating the process. However, some batches can still become unstable.

Approach 2:
The use of the novel AnSBR to treat a synthetic winery wastewater substrate over a range of 1 000 – 7 000 mg.L^{-1} was found to be feasible. It was possible to optimise the efficiency measurements affecting the performance on the AnBSR using a specific experimental design. The same overall optimal values were found for the operational parameters at two distinct COD concentrations: 4 000 mg.L^{-1} and 7 000 mg.L^{-1}. The optimal operational parameters were found to be as follows: X_1 = pH of 7.3 (range of 6.7 – 7.3 feasible); X_2 = longer feeding time (fed-batch process)) of 4 h with regard to a 24 h cycle and X_3 = mixing frequency (mixing set for 10 s every 110 min). Although the AnSBR process was found to be feasible, the legislative standards of treated wastewater disposal into a natural resource were not reached. A post-treatment or longer cycle time could be recommended.

The validation of the optimal values obtained during Experimental Study Phase B & D should be applied to a full-scale AnSBR. Therefore, further research should be conducted on a pilot scale set-up to perform the same type of optimisation research, followed by a validation experiment. It is recommended that the AnSBR process be up-scaled into a pilot scale set-up to optimise the operational parameters before up scaling the process to an industrial scale. This should be done to determine the feasibility and the cost of the process on a larger scale.

9. ACCUMULATED OUTPUTS

a) TECHNOLOGY DEVELOPED, PRODUCTS AND PATENTS

Two laboratory-scale AnSBR's were constructed, commissioned and optimised. With some further modifications and optimisation these could serve as valuable research tools for future research.

b) SUGGESTIONS FOR TECHNOLOGY TRANSFER

It is recommended that the results obtained, especially in "Approach 2" be further investigated at pilot-scale using actual winery wastewater. This will provide information as to the possible final design of full-scale AnSBR treatment systems, as well as providing valuable operational guidance for optimal operating conditions.

c) HUMAN RESOURCES DEVELOPMENT/TRAINING

Student Name and Surname	Student Nationality	Degree (e.g. MSc Agric, MComm)	Level of studies in final year of project	Graduation date	Total cost to industry throughout the project
Honours students					
Masters Students					
Marilet Laing	RSA	MSc Food Sci	2 year MSc	March 2016	R90 000
Jason Smit	RSA	M Eng	2 year MSc	December 2016	R90 000
PhD students					
Postdocs					
Support Personnel					

d) PUBLICATIONS (POPULAR, PRESS RELEASES, SEMI-SCIENTIFIC, SCIENTIFIC)

1) Smit, J. (2013). *The construction and preliminary evaluation of an anaerobic sequential batch reactor for the treatment of winery effluent*. Final Year Project Report: Chemical Engineering 478, Stellenbosch University.
2) Laing, M. (2016). Investigating the optimal operational parameters for the treatment of winery wastewater by anaerobic sequencing batch reactor (AnSBR). MSc in Food Science (*cum laude*), Stellenbosch University. March 2016.
3) Laing, M. & Sigge, G.O. 2016. Novel winery wastewater treatment: AnSBR technology. *South African Food Science and Technology (FST)*, **5**(3), 38-40.

e) PRESENTATIONS/PAPERS DELIVERED

1) LAING, M. & SIGGE, G.O. 2015. Investigating the performance of a novel Anaerobic Sequencing Batch Reactor (AnSBR) treating synthetic winery wastewater. 21st SAAFoST Biennial International Congress and Exhibition, Durban, 6-9 September 2015.
2) LAING, M. & SIGGE, G.O. 2015. Optimisation of operational parameters on a novel Anaerobic Sequencing Batch Reactor treating synthetic winery wastewater. Stellenbosch University Water

Institute & WISA Water Reuse Division One-day Symposium and SUWI Water Forum, Spier Conference Centre, Stellenbosch, 8 October 2015.
3) SMIT, J., BURGER, A.J. & SIGGE, G.O. 2015. Anaerobic Sequencing Batch treatment of winery wastewater. Stellenbosch University Water Institute & WISA Water Reuse Division One-day Symposium and SUWI Water Forum, Spier Conference Centre, Stellenbosch, 8 October 2015.
4) LAING, M. & SIGGE, G.O. 2015. Investigating the performance of a novel Anaerobic Sequencing Batch Reactor (AnSBR) treating synthetic winery wastewater. 7th IWA Specialized Conference on Sustainable Viticulture, Winery Wastes and Agri-Industrial Wastewater Management, Stellenbosch, 1-5 November 2015.
5) SMIT, J., BURGER, A.J. & SIGGE, G.O. 2015. The feasibility of using the Anaerobic Digestion Model 1 to model an anaerobic sequencing batch reactor for the treatment of winery wastewater. 7th IWA Specialized Conference on Sustainable Viticulture, Winery Wastes and Agri-Industrial Wastewater Management, Stellenbosch, 1-5 November 2015.

10. BUDGET

a) TOTAL COST SUMMARY OF THE PROJECT

YEAR	CFPA	DFTS	Deciduous	SATI	Winetech	THRIP	OTHER	TOTAL
2013					R170 000	R50 000		R220 000
2014					R205 000	R50 000		R255 000
2015					R175 000	R87 500		R262 500
					R550 000	R187 500		**R737 500**

b) FINAL BUDGET/FINANCIALS OF PROJECT

Project duration	Proposed budget	Actual cost incurred	Variance	Notes
TOTAL INCOME	**R550 00**	R737 500	R187 500	
Industry Funding	R550 000	R550 000		
PHI Funding				
Other Funding (THRIP)		R187 500		Due to the THRiP funding additional expenses in running costs were incurred which were mainly in the number of analyses done.
TOTAL EXPENDITURE	R550 000	R737 500	R187 500	
Running Expenses	R130 000	R239 500	R109 500	

Project duration	Proposed budget	Actual cost incurred	Variance	Notes
General operating costs (printing, communication, etc.)				
Local Travel	R30 000	R40 000	R10 000	
Publication costs				
Lab Analysis	R40 000	R68 000	R28 000	
Lab Consumables	R40 000	R55 000	R15 000	
Other (lab-scale AnSBR's)	R40 000	R65 000	R25 000	
Running expenses SUB-TOTAL	**R280 000**	R467 500	R187 500	
HR Administration and Project Management				
HR Technical	R30 000	R30 000		
HR Research	R60 000	R60 000		
Student Bursaries	R180 000	R180 000		
HR SUB-TOTAL	R270 000	R270 000		
OTHER EXPENSES				
SURPLUS / DEFICIT	0	0		

EVALUATION BY INDUSTRY

This section is for office use only

Project number	

Project name	

Name of Sub-Committee*	

Comments on project

Committee's recommendation

- Accepted. ☐
- Accepted provisionally if the sub-committee's comments are also addressed. Resubmit this final report by____ ☐
- Unacceptable. Must resubmit final report. ☐

Chairperson____ Date______________________

*SUB-COMMITTEES

Winetech
Viticulture: Cultivation; Soil Science; Plant Biotechnology; Plant Protection; Plant Improvement;
Oenology: Vinification Technology; Bottling, Packaging and Distribution; Environmental Impact; Brandy and Distilling; Microbiology

Deciduous Fruit
Technical Advisory Committees: Post-Harvest; Crop Production; Crop Protection; Technology Transfer
Peer Work Groups: Post-Harvest; Horticulture; Soil Science; Breeding and Evaluation; Pathology; Entomology