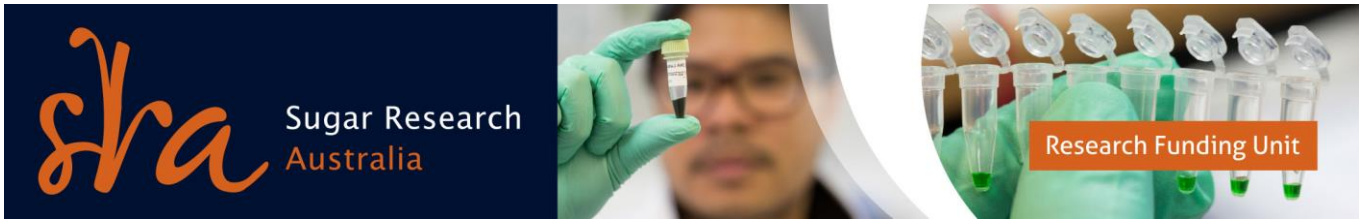


# SRA Research Project Final Report

## Flocculation and sedimentation of slow settling mud and mud cake conditioning: revised final report 2012/056

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| **SRA Project Code** | **QUT056 (SRL/QUT project number 4055) (SRA project 2012/056)** |
| **Project Title** | Flocculation and Sedimentation of Slow Settling Mud and Mud Cake Conditioning |
| **Key Focus Area in SRA Strategic Plan** | Milling efficiency and technology |
| **Research Organisation(s)** | Queensland University of Technology |
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| **Project Objectives** | The project aimed to improve the flocculation and sedimentation of slow settling mud, and reduce the pol/moisture content of mill mud by:<br>• Identifying key parameters which are associated with difficult to clarify soils;<br>• Identifying processes to improve the clarification of poor quality cane; and<br>• Identifying a strategy to condition filter cake that is difficult to process.<br>The project seeks to realize its objective by conducting physico-chemical assessment of different soils from cane fields reported to produce juices that are difficult to clarify. Results from the assessment will be used to identify an additive/process that can be used to bring about particle aggregation and improved settling of the floc particles. Permeability and compressibility parameters of mud cake obtained from the difficult to clarify soils will be conducted using a custom-built laboratory mud cake former. | | |
| **Milestone Number** | 5 | | |
| **Milestone Due Date** | 01/05/2015 | **Date submitted** | 01/05/2015 |
| **Reason for delay** (if relevant) | | | |
| **Milestone Title** | Final Report | | |
| **Success in achieving the objectives** | ☒ Completely Achieved<br>☐ Partially Achieved<br>☐ Not Achieved | | |
| **SRA measures of success for Key Focus Area (from SRA Strategic Plan)** | Adoption of improved or novel milling processes and technology | | |

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# Section 1: Executive Summary

For the Australian sugar industry to remain competitive, high clarification standards must be achieved irrespective of the quality of the cane supply in order to maintain sugar quality and minimise sugar losses in the mud cake. Mills from time to time experience periods of poor clarification performance which may be due to clay type soils coming in with the cane supply or due to increase in impurity loading in the cane supply after rainfall. The juices expressed from canes originating from the soils of Meringa, Pioneer River and Victoria Plains, to name a few, are difficult to clarify and are being evaluated in the project. Transporting mud cake to the cane fields is an expensive exercise, in part due to the high moisture content of the mud cake. Also, the amount of sugar lost to mud (~0.5% pol in cane and higher) is due to poor filterability of the mud cake. Therefore, issues around poor clarification and mud filtration performance reduce the profitability of Australian sugar mills. Thus, the aim of the project is to improve the flocculation and sedimentation of slow settling mud, and reduce the pol/moisture content of mud cake.

Soil samples were collected from sugarcane fields that are known to produce cane that when expressed results in poor juice clarification and slow settling of flocs. Also, collected where soils that have good coagulation and flocculation characteristics. These were used to help guide the development of knowledge on soils with poor flocculation and sedimentation properties.

The composition and the physicochemical properties of the soils were determined using a number of analytical tools. The soils that are likely to impact on poor coagulation/flocculation processes and those that have slow settling flocs characteristics are likely to have the following features:

- High amorphous content (>20 wt%).
- High specific surface area (>40 $m^2/g$).
- Contains Si:Al ratio of 2:1 typical of montmorillonite type composition.
- High cation exchange capacity (>5 meq/100 g).
- High zeta potential. In some cases, if the difference in zeta potential of a soil in a 0.01 M NaCl and the zeta potential of the same soil in 0.1 M NaCl is negative.

The threshold values for these features are not known. The values provided should be used as a guide.

On the basis of the composition, surface chemistry, physico-chemical properties, and coagulation properties of the soils, the following approaches were identified in the project that should be considered to address the problem: (a) addition of bagasse fly ash (pre-flocculated) to increase bulk density, and/or influence surface chemistry, (b) addition of gypsum to help dehydrate fluid in the inter-voids of the flocs, (c) fibre

content, (d) multi-flocculation, and (d) shearing of the particles to increase particle-particle collision.

The results from these studies indicated the following:

- The addition of bagasse fly ash (i.e., pre-flocculated) affected the floc structure. It improved the settling speed of soil flocs.
- The addition of gypsum changed the floc structure. Sparkling clear juice was obtained when gypsum was added prior to clarification. The settling speed of the flocs varied with soil type.
- The addition of fibre clearly demonstrated a reduction in settling speed of the flocs. The more the proportion of fibre, the slower the settling speeds of the flocs
- Multiple-flocculation improved settling speed of flocs.

A simple permeability test rig has been designed, re-designed and modified throughout the course of the project. Although the latest modification of the test rig performed a lot better than previous attempts, it was not possible to evaluate the effects of the different soils on cake permeability. Adding small quantities of soils to the underflow did not produce any differentiation in terms of filtration performance. However, the study indicated that the clarification process in which slow settling muds are formed must be improved in order to enhance filtration rate in the mud filters. It also showed that the addition of ash to mud prior to filtration improved permeability and possibly mud retention because of reduction in filtration rate.

The project has provided outputs which should be explored in order to develop processes that will improve clarification technology. The outcome from the deliberations with the Project Reference Group is that a follow-on project/or an extension of the present project should investigate all the options identified in the project.

## Section 2: Background

Clarification is the hub of the sugar manufacturing process. May sugar mills experience period of poor clarification performance. This may be due to the soil and clay types coming in with the cane supply or an increase in impurity loading in the cane supply after rainfall. During the periods of poor clarification performance, the observable effects are:

- Small mud flocs;
- Light mud which does not settle;
- High mud levels;
- High turbidity overflow juices;
- Filter cake that is difficult to wash.

The immediate response by mills to these problems is to increase the flocculant flow rate and to reduce the juice flow rate, and perhaps add phosphoric acid prior to liming. Recent work by Prof Doherty has shown that soils associated with difficult to clarify juices possess 3-D network structures caused by interactions between micro- and nano-size mineral platelets which differ in electrical charge. And so are difficult to coagulate. The approach used included the use of coagulants/additives and multi-stage dosing of flocculants.

Mill mud contains several mineral constituents which make it suitable to be used as a fertiliser, though it contains a large portion of moisture (~75-80%). High moisture content leads to high transportation costs. While distributing the mud within the vicinity of a sugar mill will save costs, it would over time, increase the heavy mineral constituents which will eventually contribute to pollution of the eco-system. The project designed a simple permeability rig that was used to study mud conditioning as a means of improving the mud cake properties to significantly reduce pol loss and moisture.

## Section 3: Outputs and Achievement of Project Objectives

### Project objectives, methodology, results and discussion

The objectives for the project as stated in the original application were as follows:

The project aimed to improve the flocculation and sedimentation of slow settling mud, and reduce the pol/moisture content of mill mud by:

- Identifying key parameters which are associated with difficult to clarify soils;
- Identifying processes to improve the clarification of poor quality cane;
- Identifying a strategy to condition filter cake that is difficult to process.

The project sought to realise its objective by conducting physico-chemical assessment of different soils from cane fields reported to produce juices that are difficult to clarify. Results from the assessment were used to identify an additive/process that can be used to bring about particle aggregation and improved settling of the floc particles. Permeability and compressibility parameters of mud cake obtained from the difficult to clarify soils were conducted using a custom-built laboratory mud cake former.

The objectives have been met in full and the report attached as an appendix details the major outputs and from the project. The request for additional funds was to provide supporting evidence on the strategies to be adopted in a follow-on project.

## Section 4: Outputs and Outcomes

The primary outputs from the project include:

- Data on the composition and physicochemical properties of soils collected from sugarcane fields that are known to produce cane that when expressed results in poor juice clarification and slow settling of flocs.
- Identification of the influencing factors that affect floc structure and settling speed of the flocs.
- Increased knowledge on juice clarification for the Australian sugar industry.
- Knowledge of the technology(ies) to address slow settling mud and mud conditioning.
- Data on the salient features of wet and dry soils.
- Data on the use of bagasse fly ash and pre-flocculated bagasse fly ash to improve floc settling rates.
- Data on the use of gypsum (and gypsum/ash) to improve juice clarification
- Data on multiple-flocculation on floc settling rate.
- Data on the effect of fine fibre (i.e., bagacillo) on the settling rate of flocs.
- Design specification of a simple permeability rig that can be used in-house in a sugar factory.

Outcome:

- Recommendations on strategies that should be examined to solve the problems of flocculation and sedimentation of slow settling mud, and mud cake conditioning.

## Section 5: Intellectual Property (IP) and Confidentiality

This project was part funded by a syndicate of Australian sugar mills. As a consequence the findings from this study are confidential to SRA, Sugar Research Limited (SRL), the syndicate of mills and QUT.

The period of confidentiality is 6 years from the date of submission of the final report. There are mechanisms to allow non-syndicate members to buy access to the project deliverables.

## Section 6: Industry Communication and Adoption of Outputs

The project has provided outputs which should be explored in order to provide the kind of information that would be of immediate benefit to the industry. The outcome from the deliberations with the Project Reference Group is that a follow-on project/or

an extension of the present project should investigate all the options identified in the project.

Information obtained from the project has been communicated to sugar factories through the yearly (2013, 2014 and 2015) QUT Regional Research Seminars.

## Section 7: Environmental Impact

There was no environmental impact resulting from conducting the project.

## Section 8: Recommendations and Future Industry Needs

The problem associated with the flocculation and the sedimentation of slow settling mud occurs in various industries apart from the sugar industry including: coal, mining, wastewater and oil. It is a grand challenge issue, and to date no solution has been found in the world. The University of Queensland and a number of consultants are currently involved in a multi-million dollar project to address this very problem for the coal industry. In the present QUT056 project, inroads have been made in trying to find solutions for the sugar industry. This is because the approach used is unique, because we sort to study the soil composition, its coagulation/flocculation properties, its physic-chemical properties, and the surface chemistry of both dry and wet soils. A follow-on project should be supported to allow some of the strategies identified to be fully explored.

## Section 9: Publications

NA