# THE EFFECT OF CLAY TYPE SOIL IN THE DIFFUSER AT UMFOLOZI MILL

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## Abstract

The major cane supply to Umfolozi (UF) mill is from the Umfolozi River flood plains, *viz* the Flats which contain soil that is rich in aluminium silicate (clay). Due to the sticky nature of the clay, it adheres to the harvested cane and ends up inside the De-Smet diffuser. Tests were done to study the effects of suspended solids and ash in diffuser inter-stage juice, that would eventually settle onto the cane bed. Suspended solids profiles indicate an increase in solids/ash concentration across the cane bed, and a decrease in solids/ash concentration in inter-stage juices. Since clay is impermeable in nature, the degree of percolation is reduced and results in flooding. When flooding occurs, imbibition and throughput have to be reduced to maintain steady operating conditions, thus compromising extraction. Removing the solids/ash from the cane entrance of the diffuser, where the solids/ash concentration in inter-stage juice is the greatest, would ensure a cleaner bed and reduce the tendency to flood. This would ensure effective percolation. Two methods of solids/ash removal will be considered, the hydro cyclone (de-sander) and the conventional clarifier.

*Keywords:* solids, ash, clay, diffuser percolation, flooding, hydro cyclone, clarification, factory process

## Introduction

Flooding in the diffuser is a problem commonly experienced at Umfolozi (UF), resulting in a sacrifice in throughput and imbibition which leads to poor extraction. Press water clarification is practiced to alleviate the flooding. Extraction is dependent on many variables, one of which is percolation. The soil type in the major cane supply regions for UF is rich in clay, and has low permeability characteristics that hinders percolation in the diffuser. Removing the suspended solids from the cane bed would allow the bed to be more permeable, thus minimising flooding and maintaining efficient extraction even during periods of high ash content.

## Experimental Work

### *Soil analysis*

Analysis of a sample of soil deposit obtained from the diffuser shows it to be inorganic in nature.It consists of more than 60% aluminium silicate, i.e. clay, carrying a negative or anionic charge. Table 1 indicates a chemical breakdown of the constituents present in the soil.

**Table 1. Analysis of diffuser soil deposit.**

| Analysis | % mass on ash | % mass on sample |
|---|---|---|
| Silicon as $SiO_2$ | 75.06 | 53.78 |
| Aluminium as $Al_2O_3$ | 11.96 | 8.57 |
| Iron as $Fe_2O_3$ | 5.99 | 4.29 |
| Manganese as MnO | 0.08 | 0.06 |
| Magnesium as MgO | 0.96 | 0.69 |
| Calcium as CaO | 1.17 | 0.84 |
| Sodium as $Na_2O$ | 1.67 | 1.20 |
| Potassium as $K_2O$ | 2.02 | 1.45 |
| Titanium as $TiO_2$ | 1.11 | 0.80 |
| Phosphorus as $P_2O_5$ | 0.18 | 0.13 |
| Chromium as $Cr_2O_3$ | 0.02 | 0.01 |
| Nickel as NiO | 0.01 | 0.01 |

At times during harvesting, the sticky nature of the clay type soil at the Umfolozi Flats makes it nearly impossible to harvest cane, even during light rainfall, due to the fact that the soil retains water and has low permeability characteristics, as shown in Table 2 (http: // www.ext.colostate.edu/ Pubs/ Garden/ 07235.html).

**Table 2. Permeability and water retention of various soil types.**

| Soil texture | Permeability | Water retention |
|---|---|---|
| Sand | High | Low |
| Loam | Medium | Medium |
| Silt | Low | High |
| Clay | Low | High |

*Percolation rate trials*

To estimate the effect of varying quantities of suspended solids on percolation rate, an experimental apparatus emulating the diffuser was constructed. Figure 1 shows the apparatus used in the trial, which consists of a PVC pipe (1600 mm length and 150 mm diameter) with a diffuser perforated screen at the end.

A known mass of shredded cane is inserted into the pipe. Ten litres of clear juice is poured into a funnel positioned at the top of the pipe. The funnel valve is released and the time taken to fill the receiving bucket is recorded. Clear juice mixed with varying amounts of mud from the press water clarifier is passed through the pipe and diffuser screen. The percolation rates are then estimated by the following formula:

Percolation rate = Volume Collected ÷ Cross Sectional Area of Pipe ÷ Time= mm/s

Figure 2 shows how the percolation rate decreases as the amount of mud (suspended solids) in clear juice increases, thus indicating that the percolation rate is reduced by high volumes of suspended solids in juice. The solids accumulate on the cane and the permeability is reduced. Tests carried out in pilot diffusion columns confirm that the presence of soil in cane affects the percolation rate negatively (Lionnet *et al.*, 2005). If this is the case in the diffuser, extraction could be affected by high amounts of suspended solids in inter-stage juice, since extraction is significantly influenced by percolation rates.


**Figure 1. Experimental apparatus used to estimate percolation rate.**

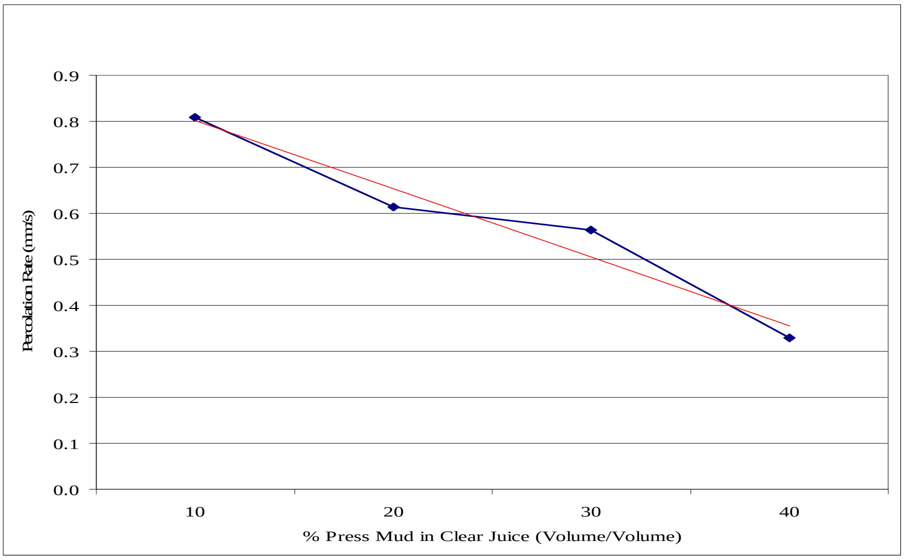


**Figure 2. Percolation rates estimated with varying amounts of press water clarifier mud in clear juice.**

## Plant trials

*Press water clarifier efficiency and impact on extraction*

UF practices press water clarification, whereby press water from the dewatering mills is screened and clarified. A 1 ppm dosage of flocculant (LT 27) is used and no lime is added in clarification, as the higher pH overflow from the clarifier will further flocculate in the diffuser and cause blinding of the cane bed. Due to the brix of the clarified press water, it is pumped towards the end stages of the diffuser, i.e. cell 3, prior to the imbibition feed stage and press water screws. To determine the efficiency of the press water clarifier, suspended solids analysis is carried out on press water, clarified press water and press water clarifier mud. The mass of solids removed from the press water is determined as the solids removal efficiency of the clarifier. Table 3 shows the typical suspended solids removal efficiencies of the press water clarifier.

**Table 3. Solids removal efficiency of the press water clarifier.**

| Trial number | Clarifier efficiency (%) | Press water flow (tons/h) |
|---|---|---|
| 1 | 25 | 167 |
| 2 | 32 | 98 |
| 3 | 14 | 241 |
| 4 | 24 | 85 |
| 5 | 22 | 90 |
| Average | 25 | 136 |

An average of 25% solids removal is achieved; however, the solids removal efficiency of the clarifier is reduced when the inlet press water flow is increased, for example to 241 tons/h. Using 25% solids removal efficiency in the press water clarifier, the amount of suspended solids returned to the diffuser in clarified press water (cpw) is determined. Figure 3 shows the trend of extraction decreasing as the amount of suspended solids in the clarified press water returning to the diffuser increases.

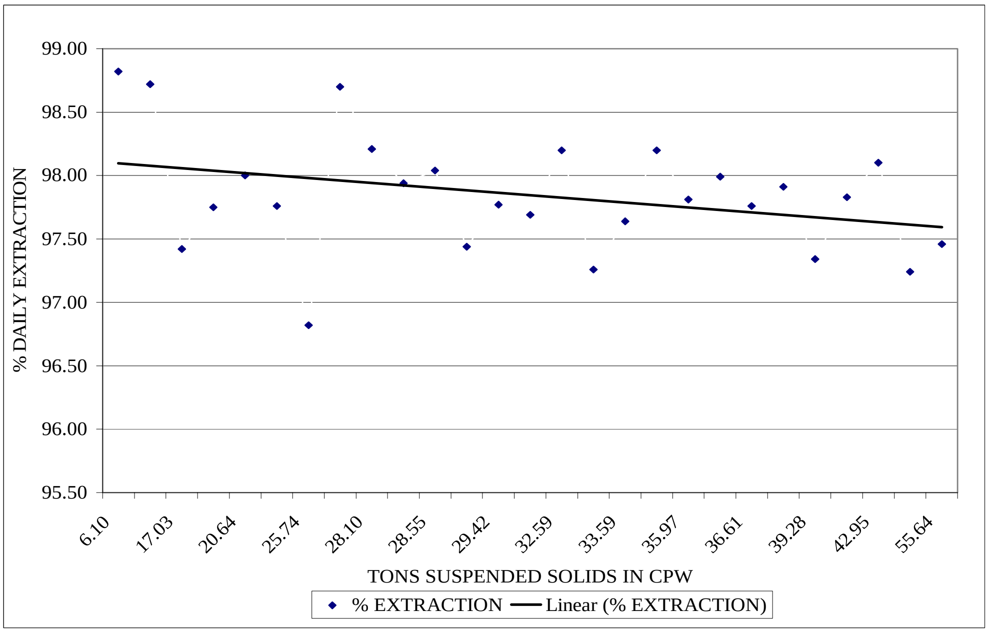


**Figure 3. Daily extraction versus clarified press water suspended solids returned to the diffuser at stage 3.**

*Suspended solids profile on diffuser inter-stage juice*

Composite inter-stage juice samples from the diffuser were tested for suspended solids % stage juice over a period of two weeks. The results are plotted as Figure 4.

The trend indicates that the suspended solids in inter-stage juice increase from cell 1 to the draft juice discharge end of the diffuser.

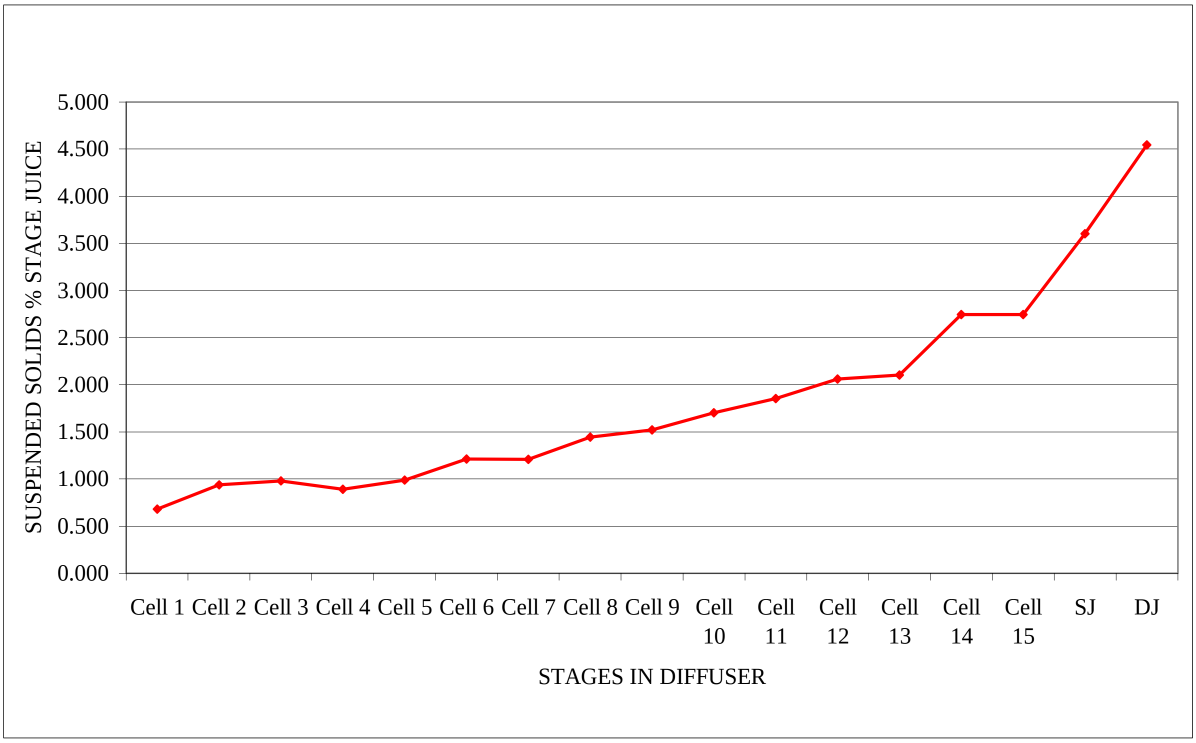


**Figure 4. Diffuser suspended solids profile in stage juice.**

*Ash profile on diffuser cane bed*

To further observe suspended solids behaviour in the diffuser, the estimation of soil in the cane bed was done by thermal decomposition (oven at 650ºC) and quoted as ash % cane. Figure 5 shows that the ash in the cane bed increases as the bed moves across the diffuser, hence the solids from the inter-stage juice accumulates on the cane bed.

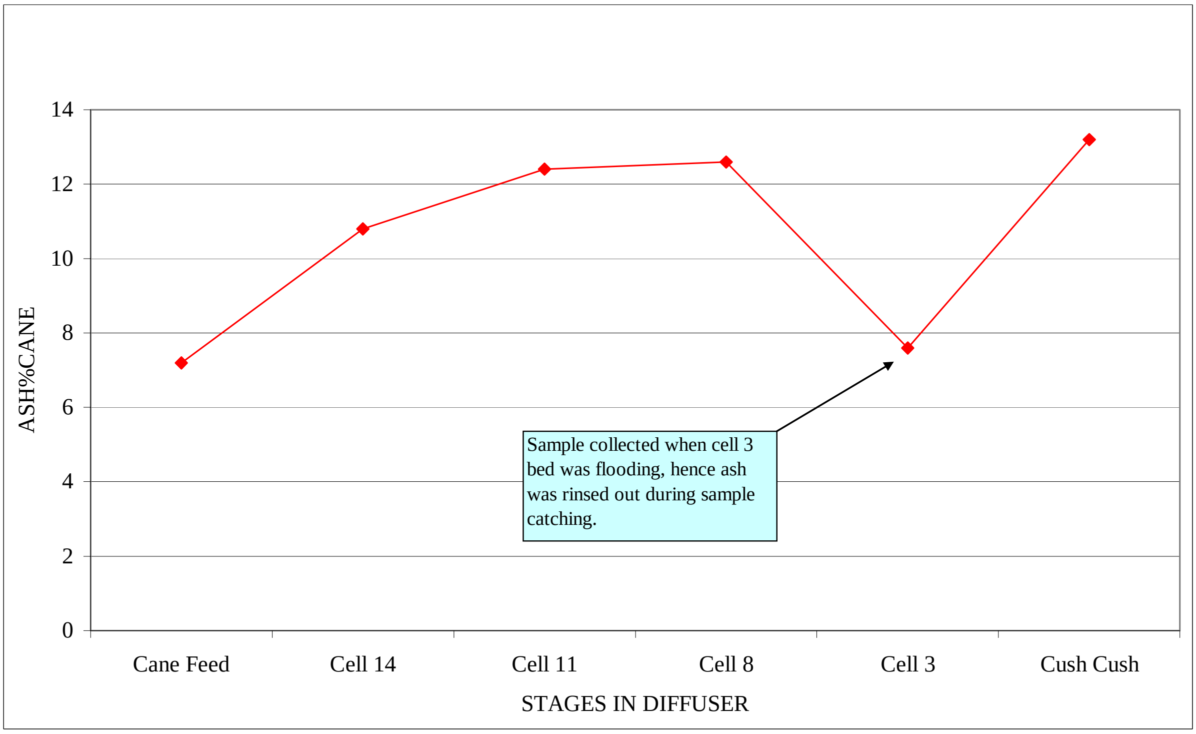


**Figure 5. Diffuser cane bed ash profile.**

*Impact of inter-stage juice suspended solids profiles on extraction*

During the two week trial, trends from the suspended solids profiles indicate that extraction is lower when there is a high amount of suspended solids in inter-stage juice, and is higher when the suspended solids content in inter-stage juice is less. Figure 6 shows the extractions obtained as the suspended solids profiles in the inter-stage juice varied.

Day 1 (squares) has the highest suspended solids in inter-stage juice, as a result poor percolation conditions were experienced. Imbibition was reduced to eliminate flooding, which led to an extraction rate of 96.65%.

Day 2 (triangles) has the lowest suspended solids in inter-stage juice. The reduced amount of suspended solids in inter-stage juice resulted in optimum percolation conditions. Imbibition was adequately applied, resulting in an extraction as high as 98.34%.

On Day 3 (circles) the suspended solids in inter-stage juice were intermediate. The operating conditions were such that an intermediate extraction of 97.77% was achieved.

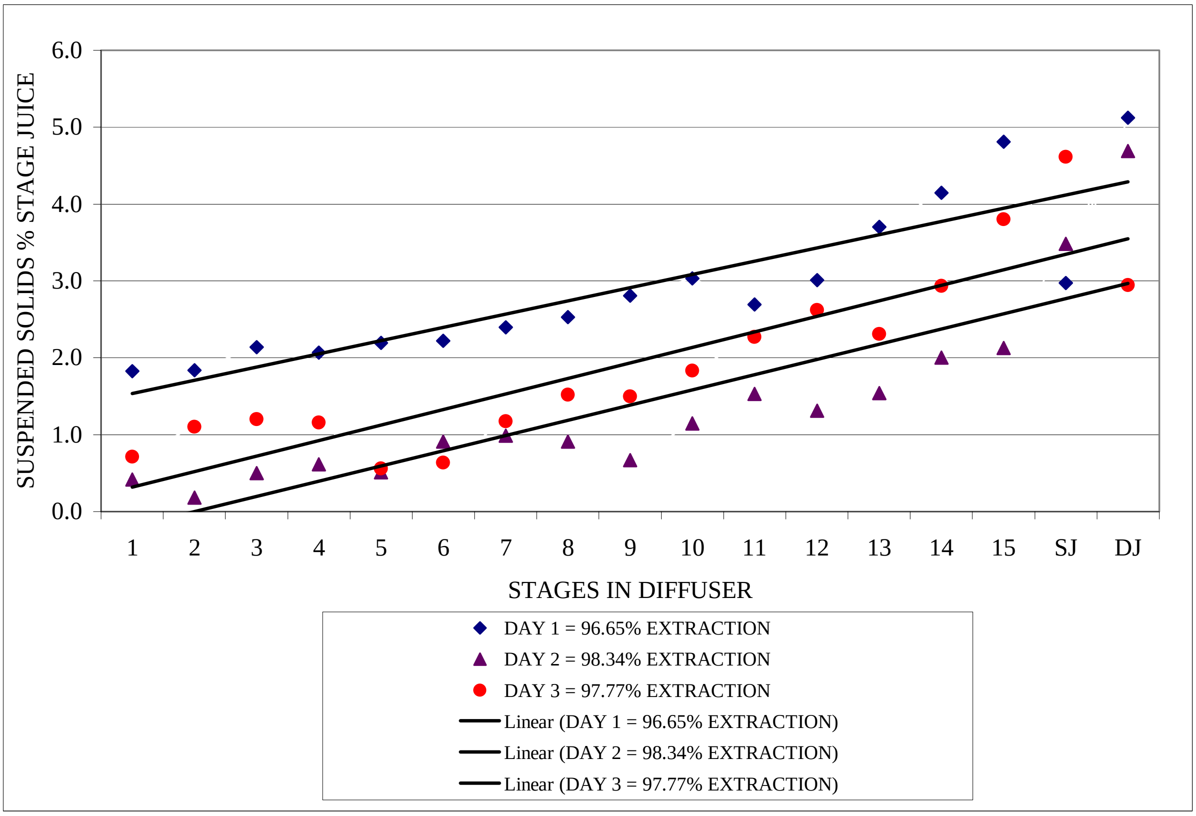


**Figure 6. Suspended solids in inter-stage juice versus extraction.**

*Discussion of plant trials*

The ash and suspended solids profiles of the cane bed and inter-stage juice indicate that, as cane entering the diffuser is rinsed by the scalding juice, the highest amount of solids in the inter-stage juice is at the cane entrance of the diffuser. The draft juice DSM screens have an aperture size of 0.75 mm to ensure that minimum solids are passed through to the mixed juice. The solids are thus accumulated with the cush cush that is returned to the cane bed. The solids are circulated in the diffuser by the inter-stage juice and gradually settle on the cane bed. Hence the ash content of the cane increases as it reaches the exit of the diffuser.

The suspended solids settling on the cane bed consist mostly of clay, which has a low permeability. If the amount of solids accumulated is high, the percolation in the diffuser will be adversely affected. This is illustrated in Figure 6, with extraction dropping as ash increases. This situation is further aggravated when the cells eventually flood due to a reduced percolation rate, where the exiting juice has a lower flow rate than the juice entering the cell. Even when the entering flow is throttled, the flooding persists, imbibition is sacrificed and throughput is eventually compromised.

## Conclusion

The highest amount of suspended solids present in inter-stage juice is noted to be at the cane entrance of the diffuser. Removing the solids at this point will reduce the accumulation of solids on the cane bed, and thus maintain optimum conditions for efficient percolation. Two methods of suspended solids removal from inter-stage juice will be explored during the 2006/7 season to alleviate flooding and improve diffuser operating conditions. Due to its high flow rates, direct clarification of scalding juice is not a viable option. The scalding juice will be pre-treated with the use of a hydro cyclone, and the underflow stream containing a concentrated amount of suspended solids will then be clarified. This clarified mud will be filtered at the filter station and the clarifier overflow will be returned to the diffuser.


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## REFERENCE


Lionnet GRE, Pillay M and Thibela B (2005). The effect of selected factors on percolation in pilot diffusion columns. *Proc S Afr Sug Technol Ass* 79: 249-257.