



INFLUENCE OF CARBON-TO- NITROGEN RATIO ON CARBOXYLIC ACIDS PRODUCTION FROM MIXED WASTEWATER SLUDGE AND PRETREATED BAGASSE FERMENTATION

**By: Prof. Romeela Mohee and Mrs
Hema Rughoonundun**

Presented by : Pratima Jeetah

1st International Conference on Waste Management in
Developing and Transient Economies,
5 – 8 September 2011, Mauritius



INTRODUCTION

- In Mauritius, around 120,000 tons of dry sludge is produced per year and this is expected to increase in the near future.
- On a volume basis, sludge is the largest constituents removed from wastewater, and it accounts for 50% cost of WWTP operation.
- Sludge can be used as a source of energy recovery from carboxylic acid produced during fermentation



INTRODUCTION

The right balance of nutrients is an essential requirement for all microorganisms-based processes. In the case of anaerobic fermentation, lack of nutrients can lead to problems such as slowing down of the process, instability of the process and reduction of fermentation products yield.



CO-DIGESTION WITH WASTEWATER SLUDGE

- Co-digestion, is an effective and economical method which seeks to optimize nutrients balance such as carbon-to-nitrogen ratio among others, thereby enhancing carboxylic acid yield during fermentation.
- These carboxylic acids can further be converted to esters and finally to mixed alcohols, that can be used as fuel as a source of energy.



CO-DIGESTION

- In this study, the combination of sludge and bagasse was chosen as bagasse is mainly cellulose, which is rich in carbon but low in nutrients, whereas, sludge is richer in terms of nitrogen and other nutrients and contains less carbon.



AIMS OF THE STUDY

The aim of this study was to

(1) Analyse the effect of C/N ratio on the yields of carboxylic acids which can be converted to liquid fuel, and

(2) Determine the effect of C/N ratio on the composition profile of carboxylic acid.

MATERIALS

- Mixed sewage sludge from Burton's Creek Treatment Plant and lime-treated bagasse were used as substrates.

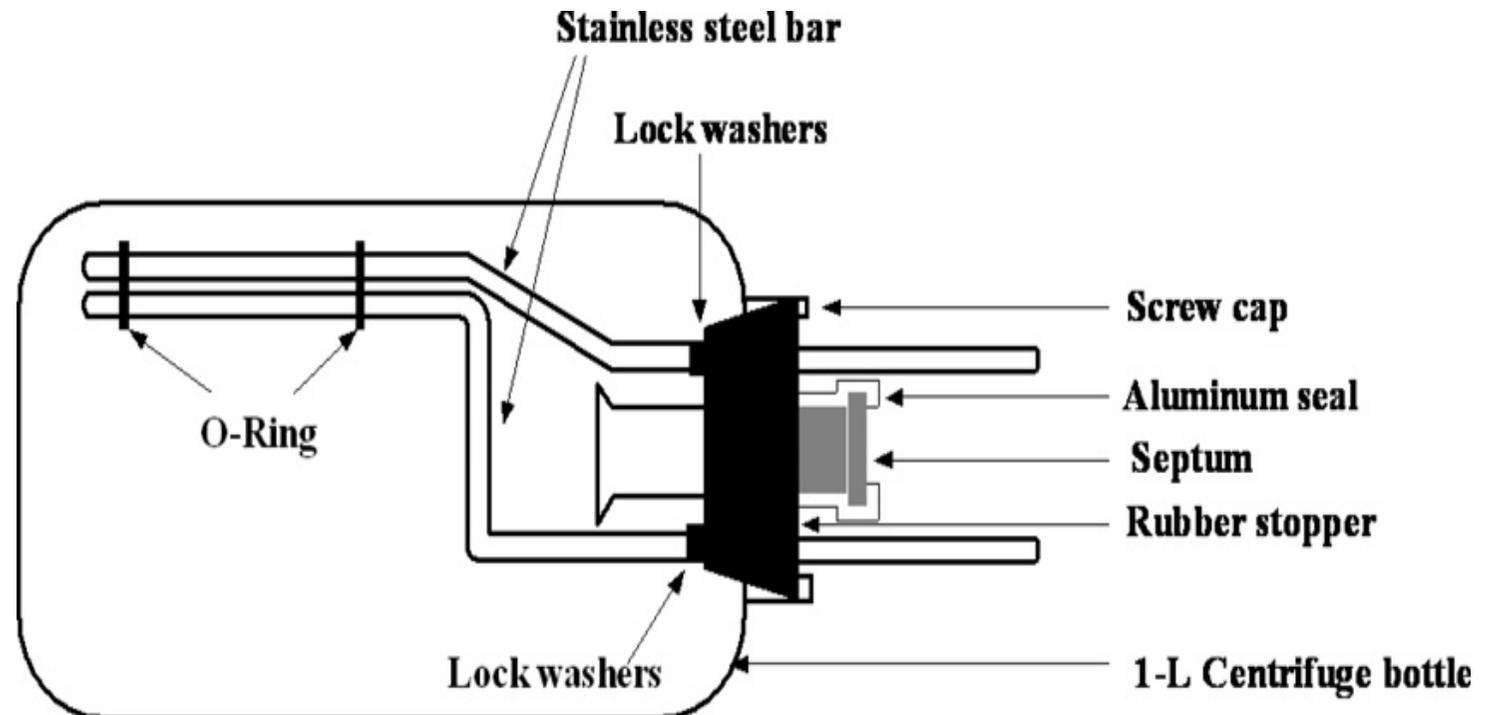


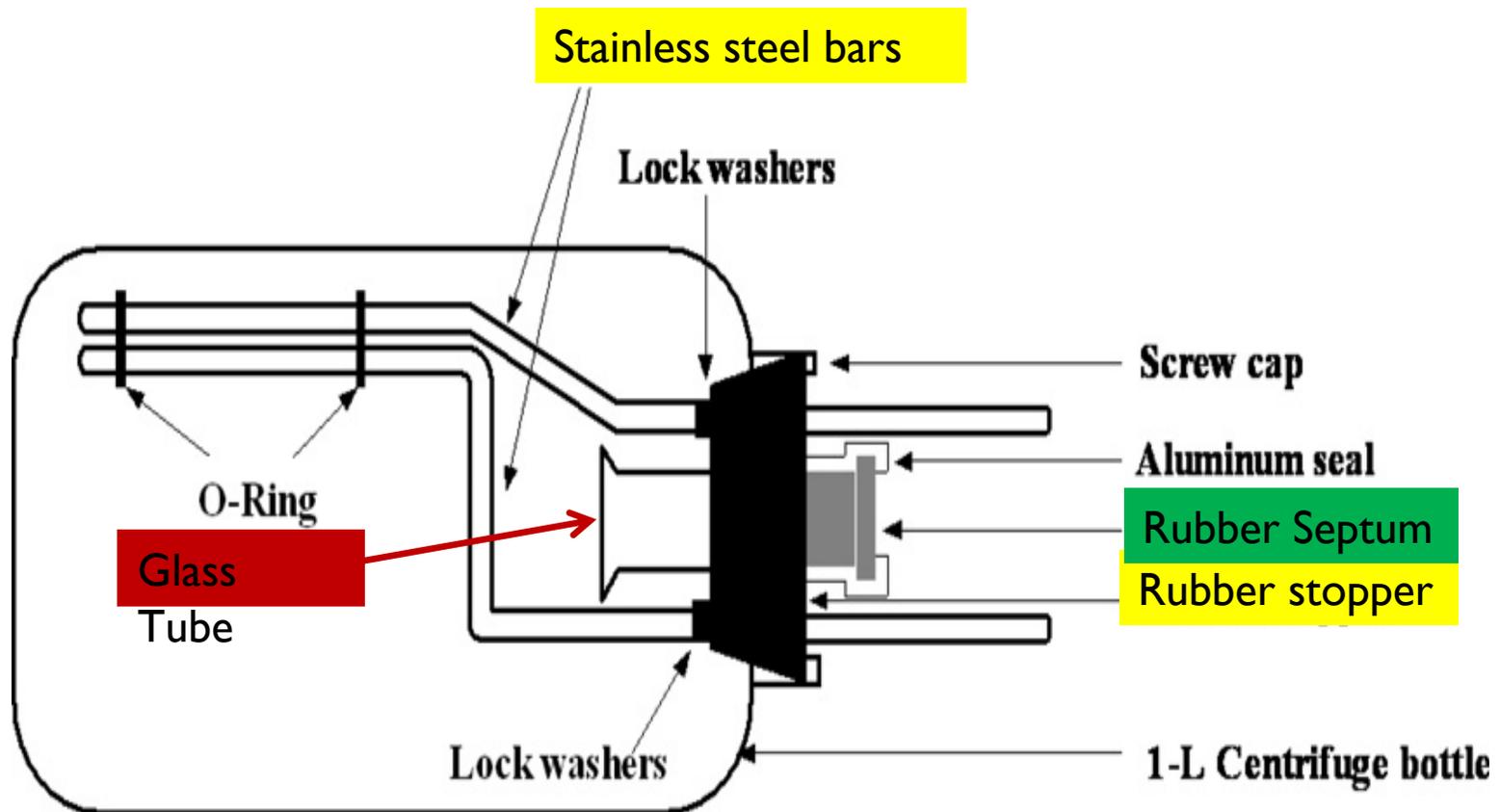
- The bagasse was mixed with 0.3 g Ca(OH)_2 /g dry biomass and distilled water and pretreated at 50°C for 8 weeks in the presence of oxygen.

METHODS

Apparatus

- The fermentor was assembled from a 1-L polypropylene centrifuge bottle





- The centrifuge bottle was capped with a rubber stopper that had a glass tube inserted in the center.
- The glass tube was capped with a rubber septum for gas sampling and venting. To enhance mixing, two pieces of stainless steel bars, were inserted through the rubber stopper.



Fermentation media and Conditions

- Fermentation was performed at 55°C.
- Sludge and pretreated bagasse were combined so as to vary the relative percentage of sludge from 0 to 100%, based on a dry weight basis.



pH control

- Every 2 days samples of the fermentation broth were taken for Volatile Fatty Acids (VFA) analysis.
- The pH was adjusted by adding ammonium bicarbonate buffer until a pH close to 7 was obtained.



Methanogens inhibitor

- To prevent conversion of carboxylic acids to methane, iodoform (CHI_3) was used as inhibitor.
- The iodoform crystals were dissolved in ethanol (20 g CHI_3 /L ethanol) and added to the fermentation substrates on alternate days.



Carboxylic acid determination

- The concentration of mixed carboxylic acid in the fermentation liquor were measured by the Agilent 6890 gas chromatograph equipped with a flame ionization detector (FID) and a 7683 series injector.

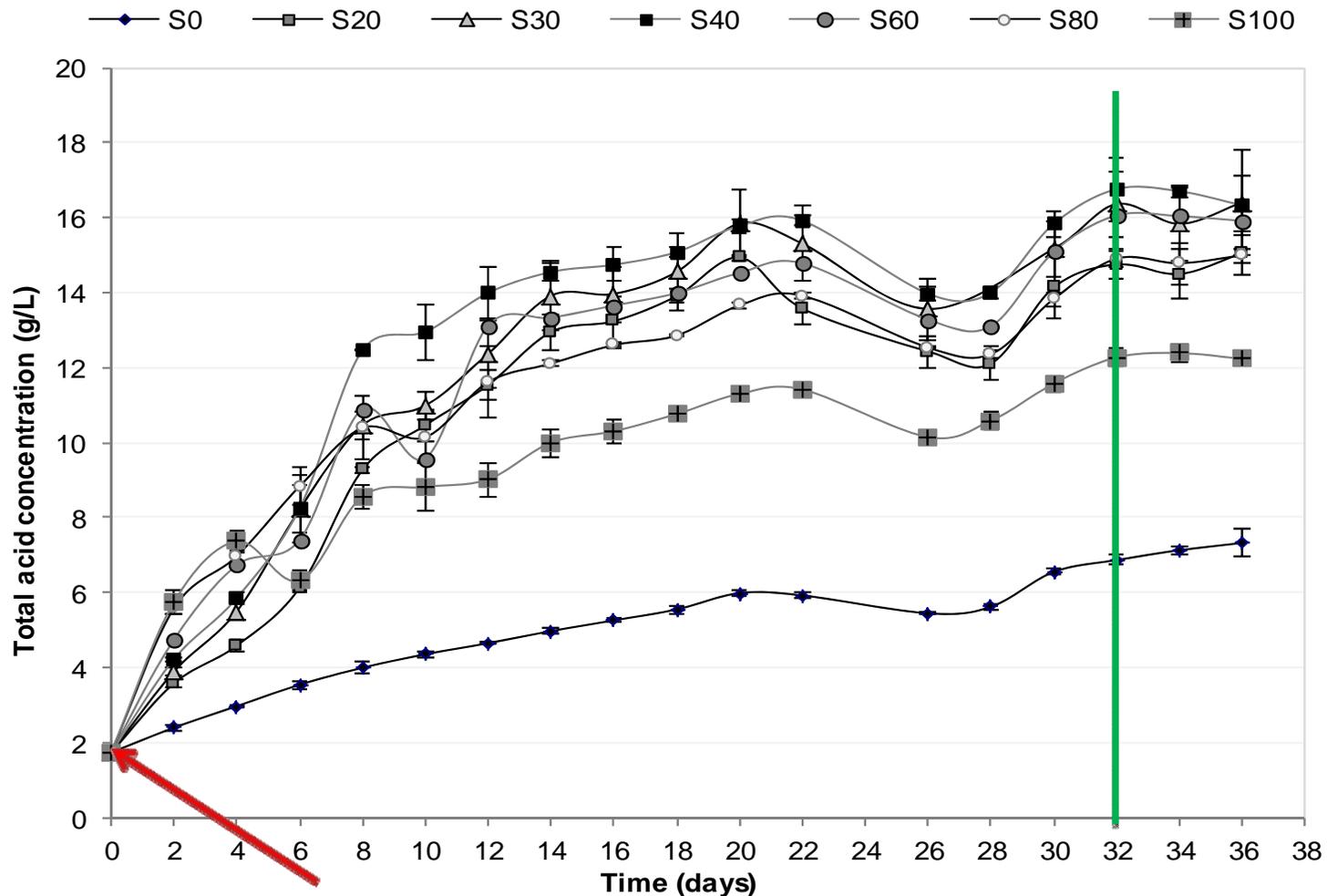


RESULTS & DISCUSSION

Carbon to Nitrogen ratio

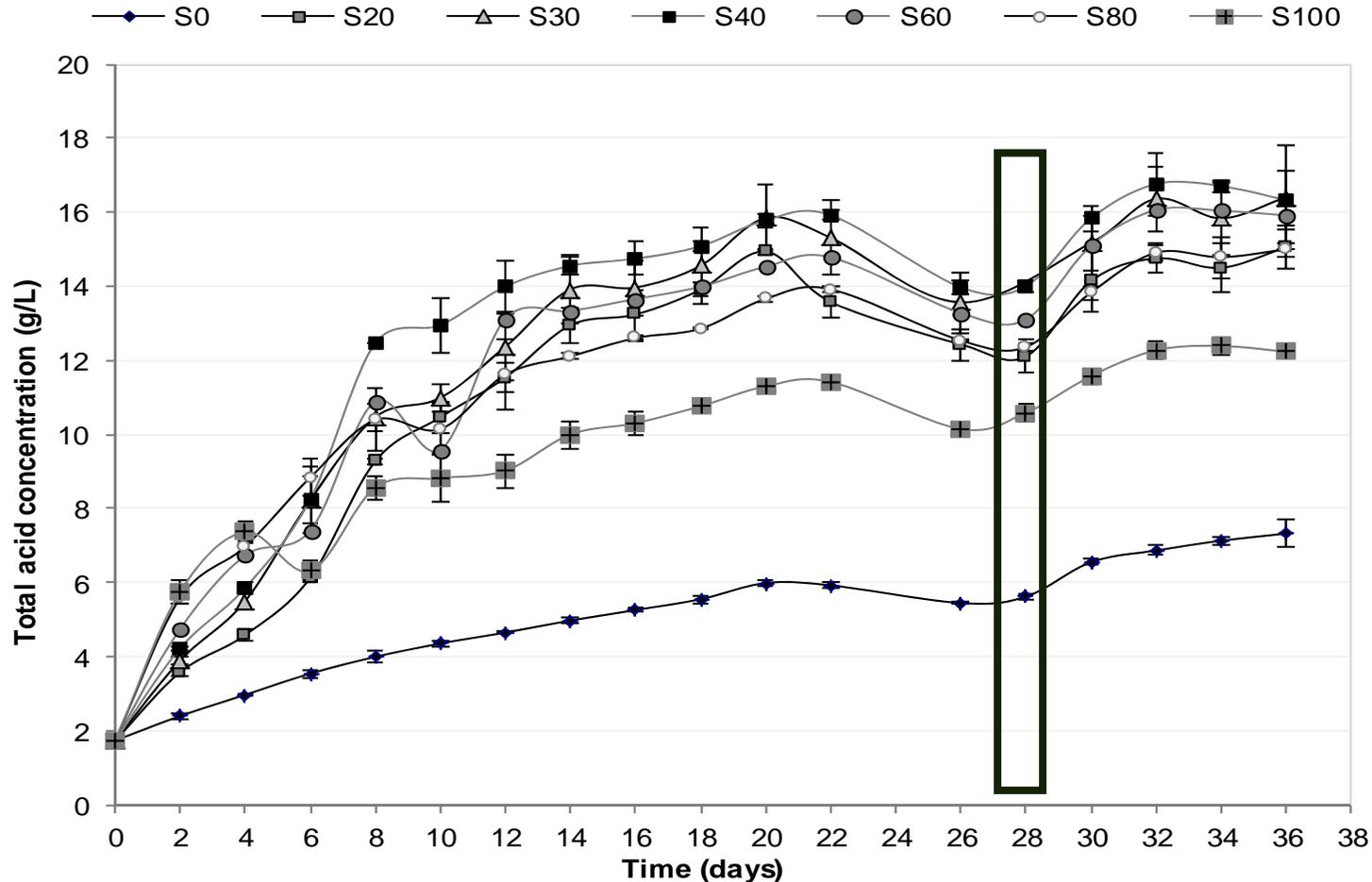
	Mixtures	C/N ratio based on Total organic mass
Bagasse Only	S_0	64.58
	S_{20}	31.76
	S_{30}	24.53
	S_{40}	19.56
	S_{60}	13.19
	S_{80}	9.27
Sludge Only	S_{100}	6.62

Carboxylic acid yield



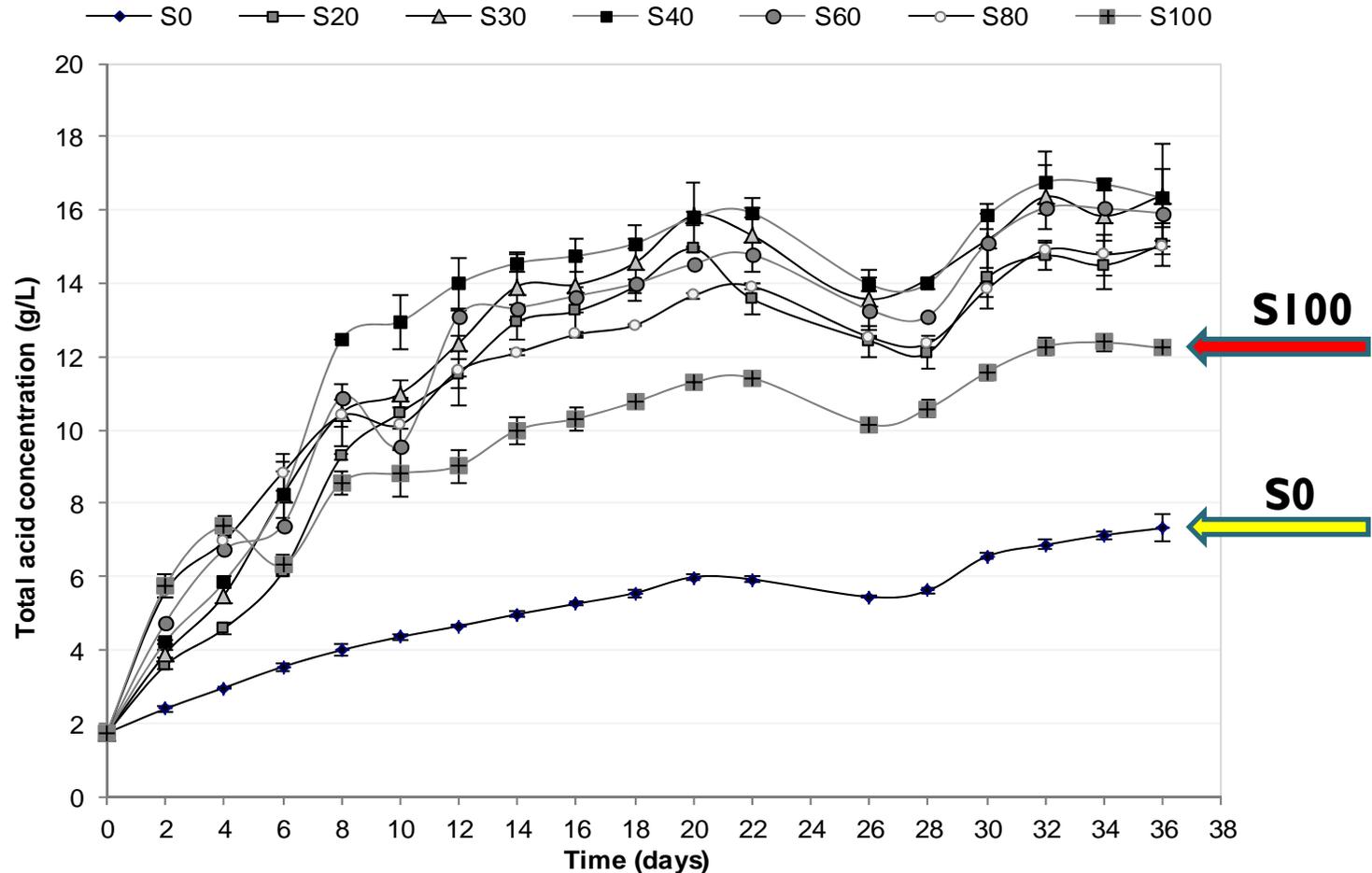
- Stabilization of the acid concentration occurred as from 32nd day.
- The total acid concentration when time is 0 corresponds to the acid contributed by the inoculum.

Carboxylic acid yield



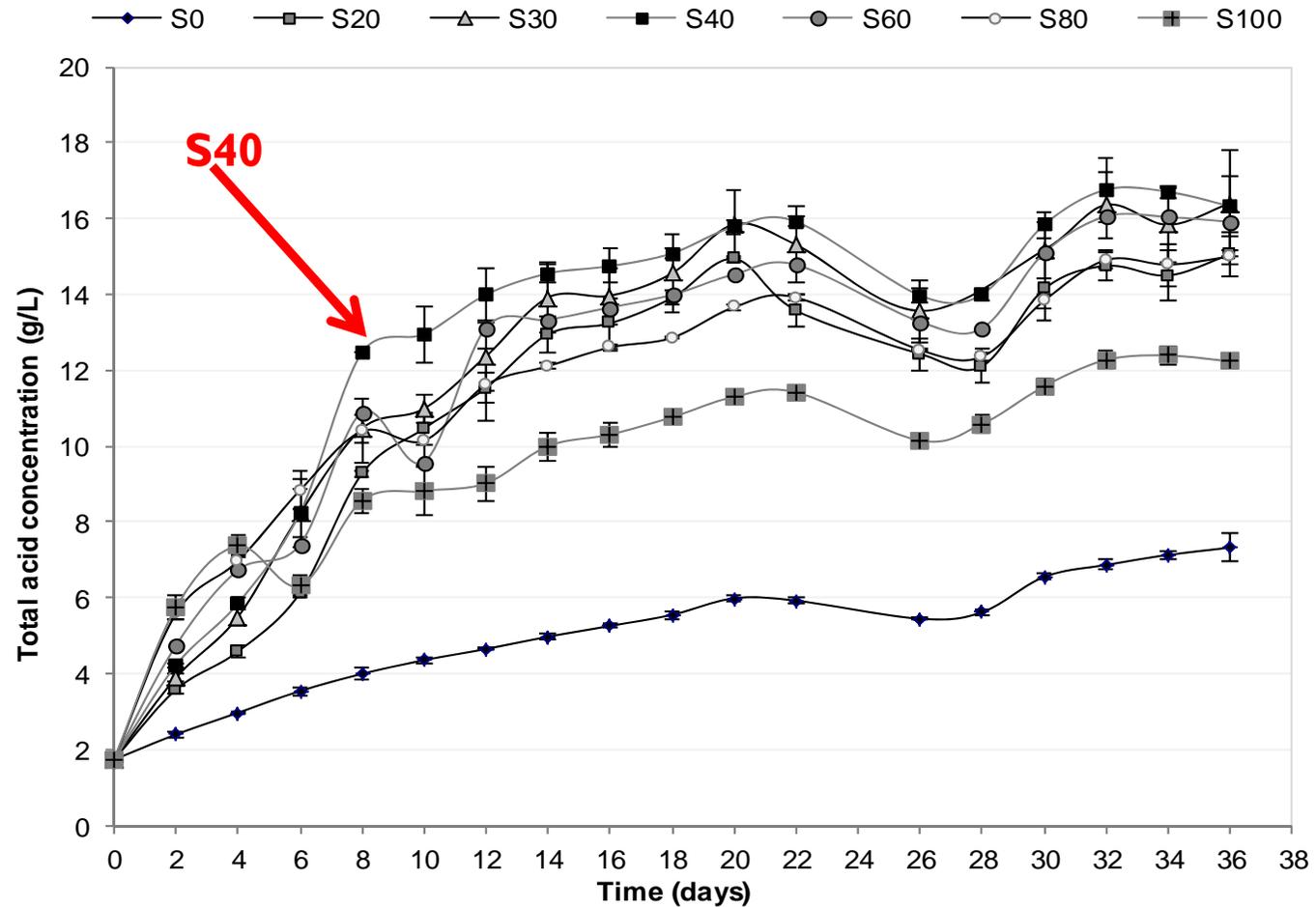
A slight decrease in acid concentrations is observed on the 28th day for all mixtures, but the mixed acids production again increased.

Carboxylic acid yield



When comparing single substrate fermentation, it was observed that mixed sewage sludge (S_{100}) consistently produced higher acid concentration than pretreated bagasse alone (S_0).

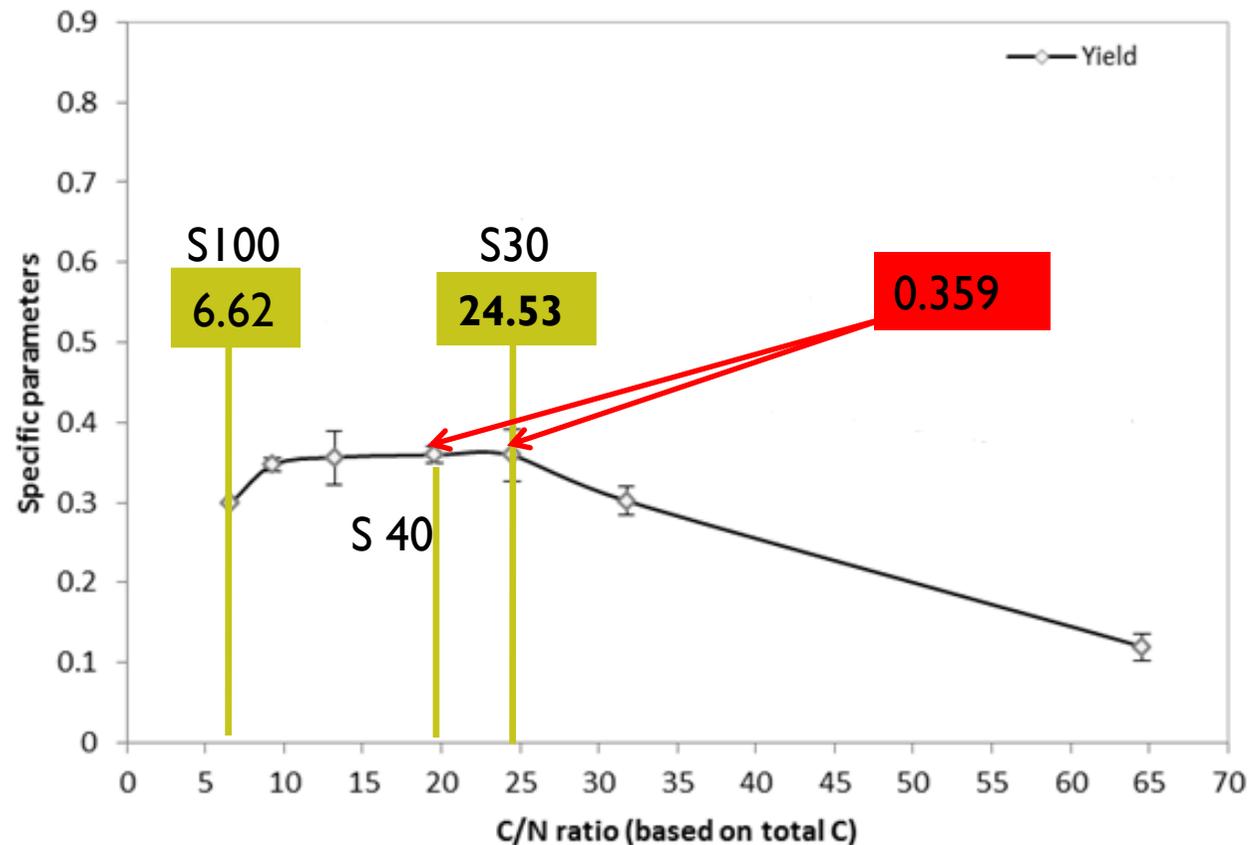
Carboxylic acid yield



Further observation of the graph shows that mixture S₄₀, comprising 40% by weight dry sewage sludge and 60% pretreated bagasse, consistently produced the highest carboxylic acids concentration as from 8th day onwards

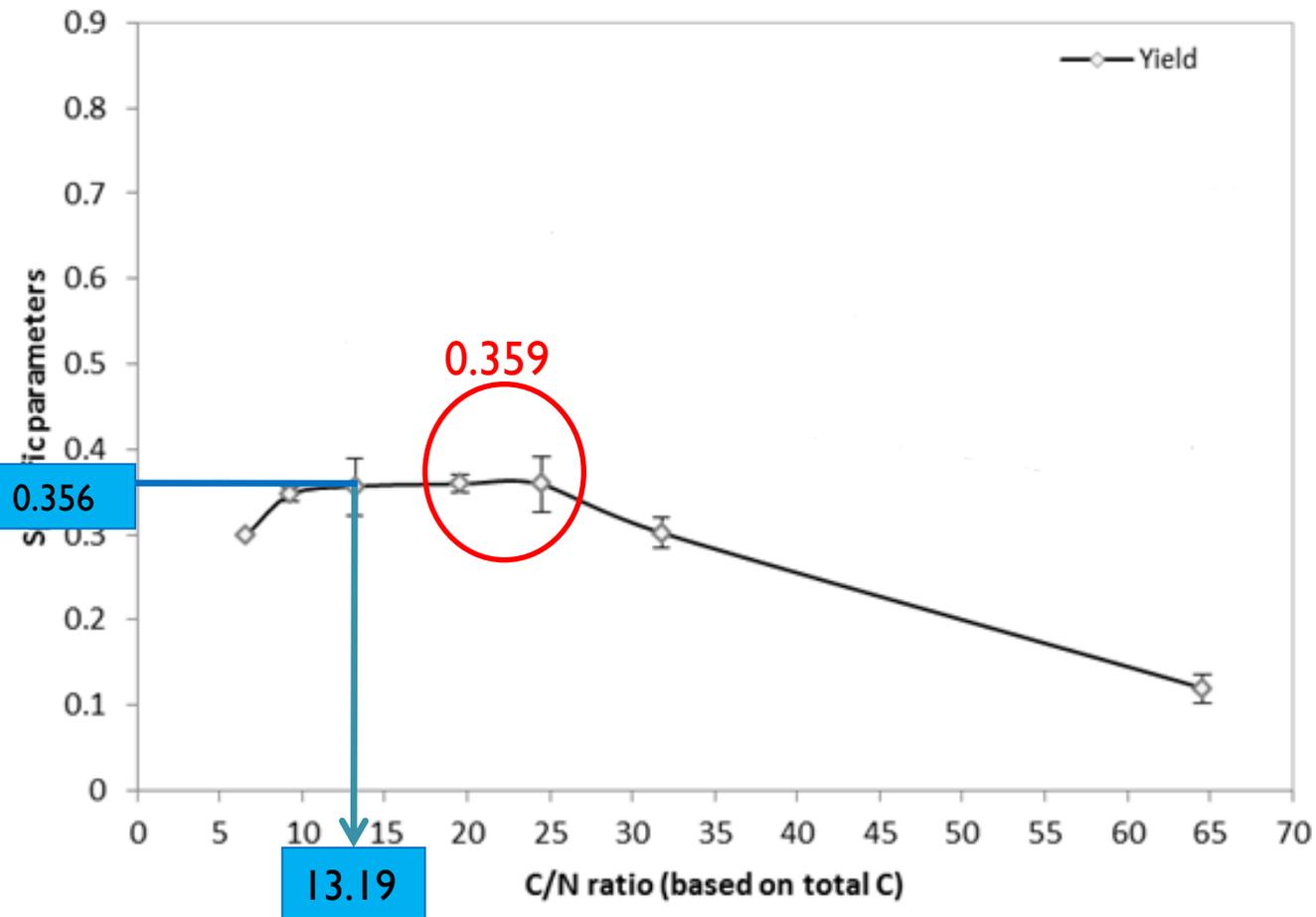
Relationship between yield and C/N ratio

- The parameter of prime significance for industrial operation is yield as a function of C/N ratio.



Increasing carbon content from 6.62 (S₁₀₀) to 24.53 (S₃₀) entailed a corresponding increase in the yield of total carboxylic acids up to a peak yield of 0.359 g acids/g VS fed.

Relationship between yield and C/N ratio



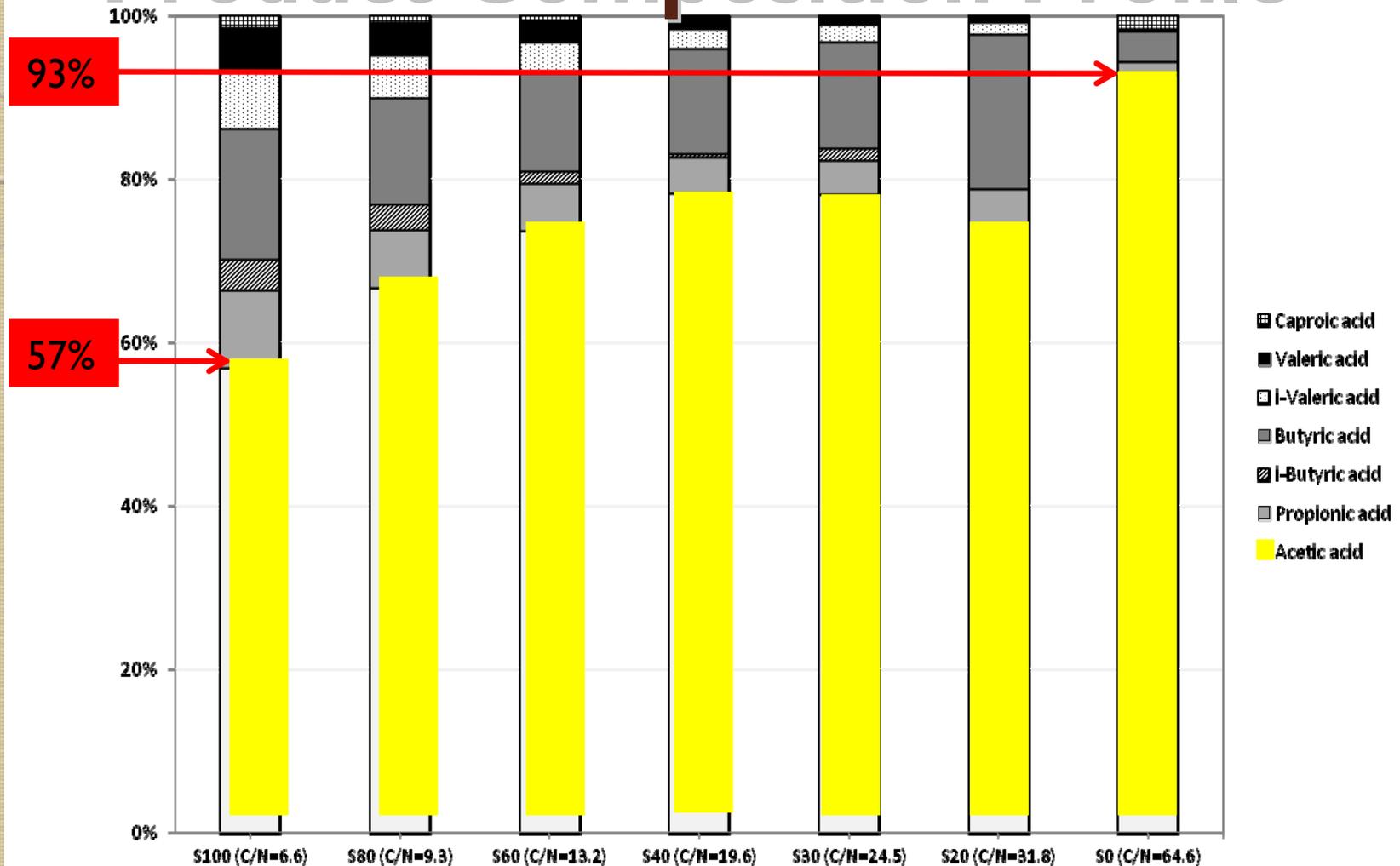
- Additionally, it is to be noted that at C/N of 13.19, the yield was 0.356 g acids/g VS fed, which is close to the maximum yield.



Product Composition Profile

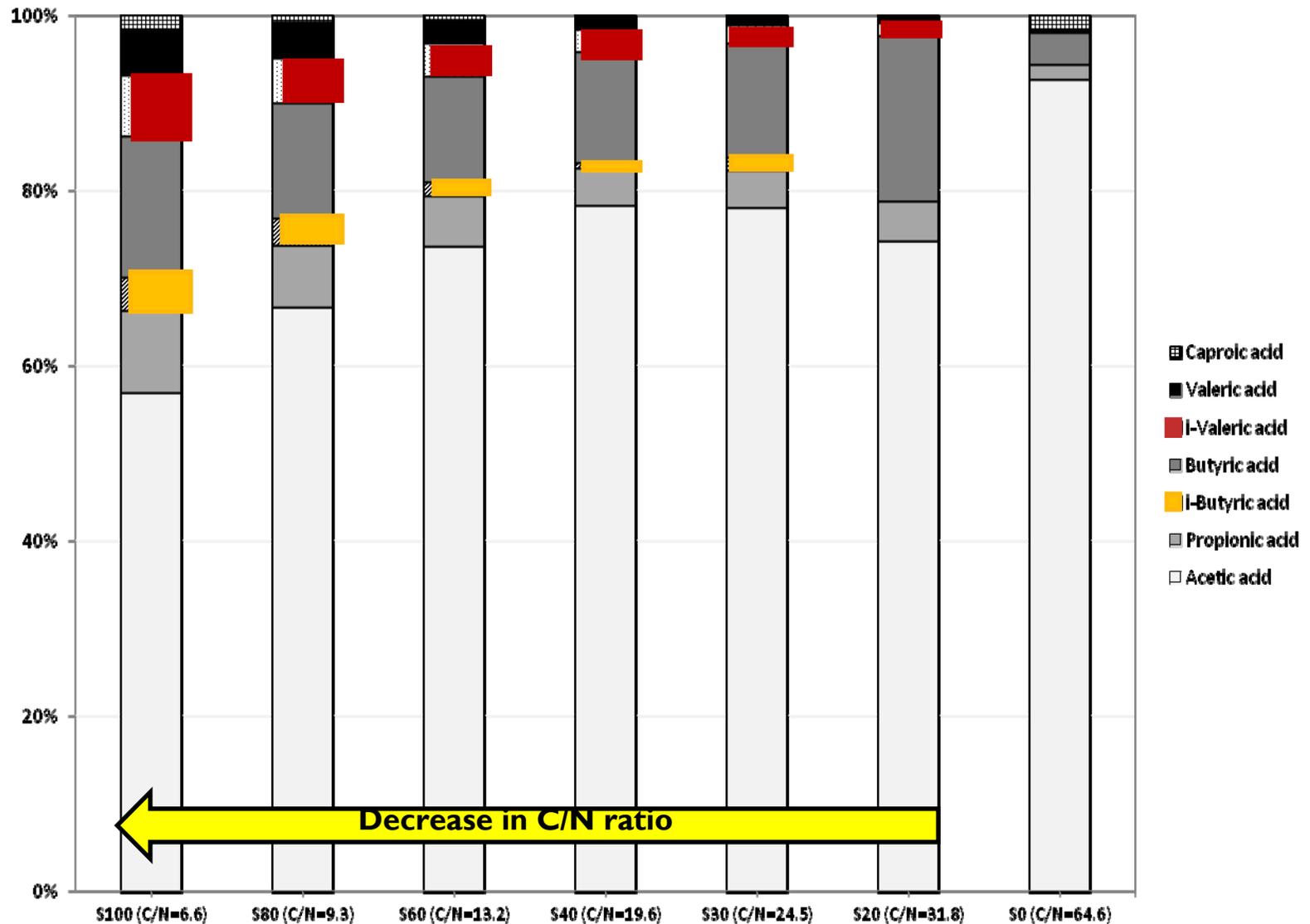
- The total carboxylic acids was analyzed for individual VFA namely in term of :
 - Acetic acid
 - Propionic acid
 - Iso-butyric acid
 - Butyric acid
 - Iso-valeric acid
 - Valeric acid
 - Caproic acid
 - Heptanoic acid

Product Composition Profile



- It is observed that acetic acid constitutes the major fraction in all the mixtures regardless of the composition of sludge and bagasse.
- The composition of acetic acid fraction ranged from 57% for sludge only (S_{100}) to 93% for bagasse only (S_0).

Product Composition Profile



It is further observed that as the C/N ratio decreases, higher percentage composition of *i*-butyric and *i*-valeric acids were observed in the



CONCLUSIONS

- Co-digestion of wastewater sludge and bagasse gave higher carboxylic acids yields than either substrate fermented on its own.
- The highest acid yield was obtained for C/N ratio ranging from 20 to 25.



CONCLUSIONS

- Only about 30% of the VS fed is converted to mixed carboxylic acid.
- Initial C/N ratio of the mixture affects the composition profile of the acids produced.



THANK YOU

Modern technology

Owes ecology

An apology

Alan M. Eddison