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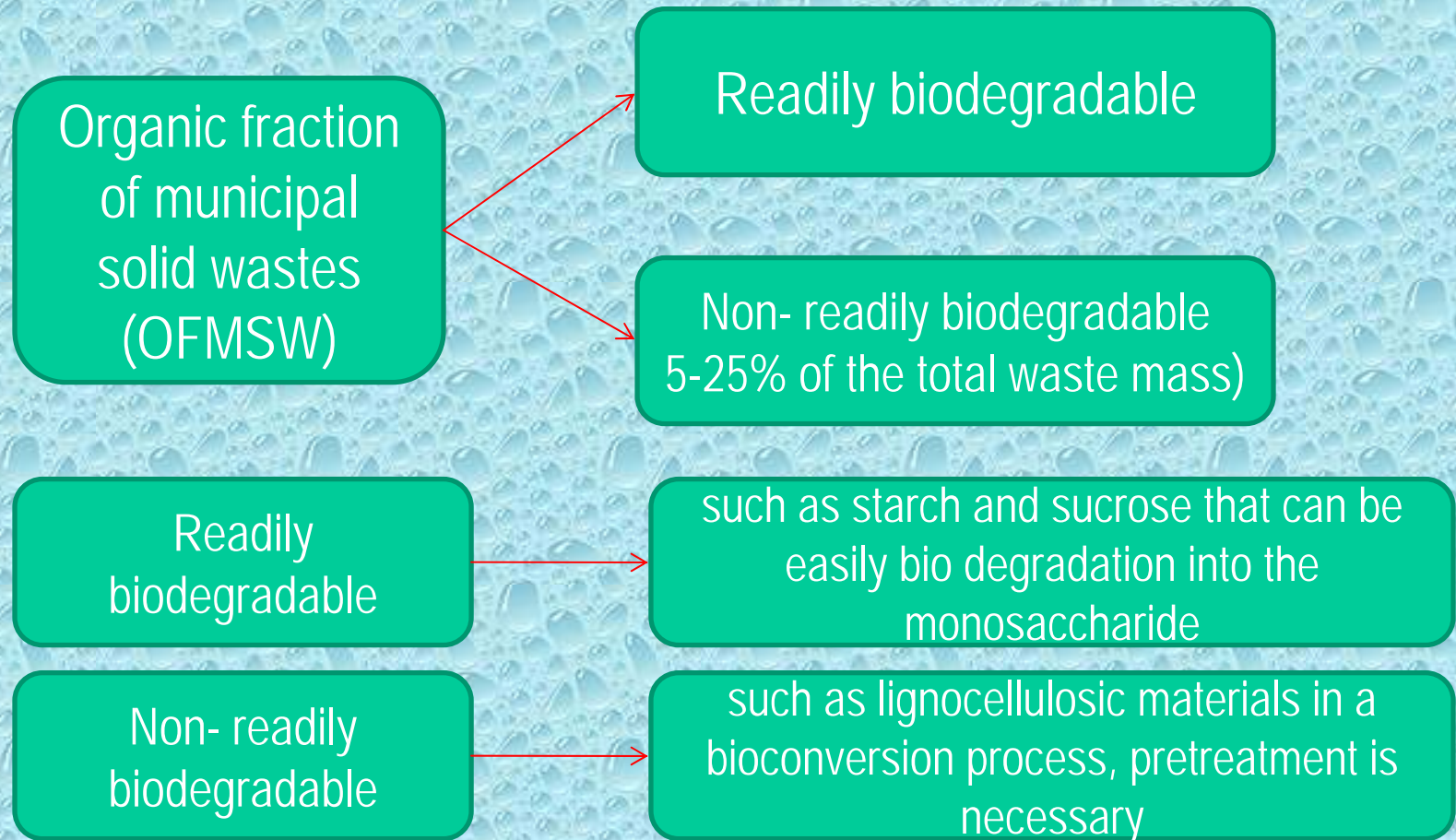
Optimization of NaOH thermo-chemical pretreatment process for enhancing solubilization of rice straw by Response Surface Methodology in order to prevention of water resource pollution

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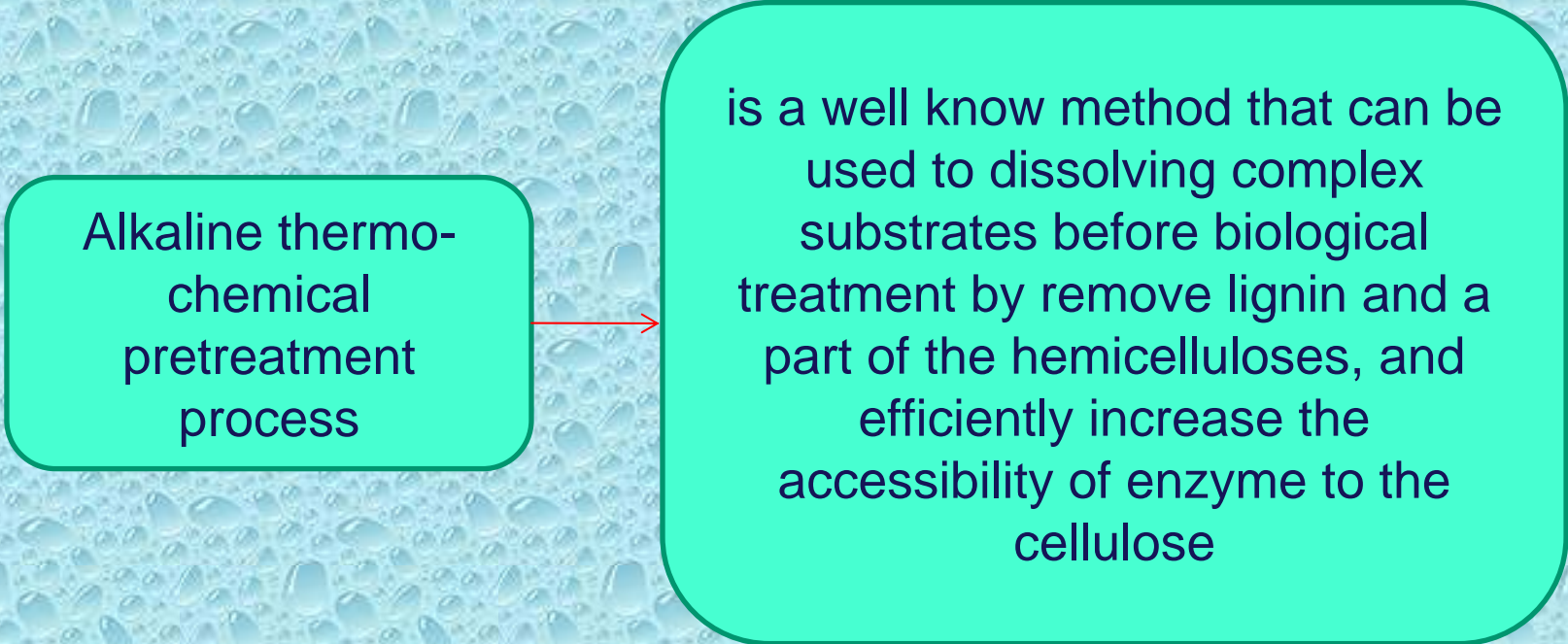


INTRODUCTION



Thermo chemical pretreatment

Alkaline thermo-
chemical
pretreatment
process



is a well know method that can be used to dissolving complex substrates before biological treatment by remove lignin and a part of the hemicelluloses, and efficiently increase the accessibility of enzyme to the cellulose

Main objectives

Identification the optimum conditions for enhancing of rice straw dissolving by response surface methodology (RSM).

Determination of physicochemical property of rice straw

Simulation the cellulose solublization reaction by Equation

Maximum SCOD

Means

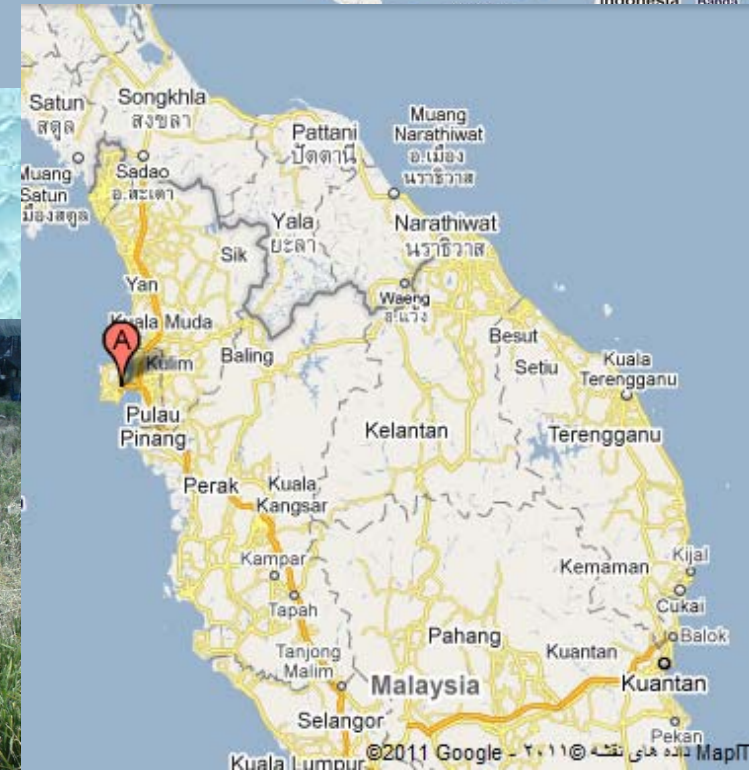
ability to produce maximum methane gas in anaerobic process

minimum residual of un-compostable materials in compost process

Collection of sample

Around 10 kg of rice straw was collected from local farm of Sungai Dua in Pulau Penang

Firstly, rice straw was cut to 5-10cm length, washed thoroughly with tap water and then air-dried. It was then grinded to 2-3mm size and used for further treatment.



Response surface methodology

| Factor | variable | Coded levels of variables | | | | |
|----------------------------|----------|---------------------------|------|-----|------|-----|
| | | -1 | -0.5 | 0 | 0.5 | 1 |
| Temperature, °C | A | 30 | 72.5 | 115 | 157 | 200 |
| time, min. | B | 10 | 52.5 | 95 | 137 | 180 |
| NaOH Concentration, g/L | C | 0 | 7.5 | 15 | 22.5 | 30 |

Rice Straw: before and after Hydrolysis process



ANOVA analysis for the quadratic model

| Source | Sum of Squares | Degree of freedom (DF) | Mean Square | F Value | Prob > F | |
|----------------------|----------------|------------------------|-----------------|---------|----------|----------------|
| Model | 2.782E+008 | 9 | 1.513E+008 | 19.09 | < 0.0001 | significant |
| A | 1.302E+008 | 1 | 2.782E+008 | 35.11 | 0.0001 | |
| B | 4.718E+008 | 1 | 1.302E+008 | 16.43 | 0.0023 | |
| C | 2.799E+007 | 1 | 4.718E+008 | 59.55 | < 0.0001 | |
| A2 | 8.495E+006 | 1 | 2.799E+007 | 3.53 | 0.0896 | |
| B2 | 7.961E+007 | 1 | 8.495E+006 | 1.07 | 0.3248 | |
| C2 | 5.787E+007 | 1 | 7.961E+007 | 10.05 | 0.0100 | |
| AB | 2.350E+008 | 1 | 5.787E+007 | 7.30 | 0.0222 | |
| AC | 9.853E+007 | 1 | 2.350E+008 | 29.66 | 0.0003 | |
| BC | 2.782E+008 | 1 | 9.853E+007 | 12.44 | 0.0055 | |
| Residual | 7.922E+007 | 1 | 7.922E+006 | | | |
| Lack of Fit | 7.904E+007 | 10 | 1.581E+007 | 429.82 | < 0.0001 | No significant |
| Pure Error | 1.839E+005 | 5 | 36777.29 | | | |
| Cor Total | 1.441E+009 | 5 | R-Squared | 0.9450 | | |
| Std. Dev. | 2814.65 | 19 | Adj. R-Squared | 0.8955 | | |
| Mean | 8923.33 | | Pred. R-Squared | -0.6740 | | |
| Critical Value (C.V) | 31.54 | | Adeq. Precision | 19.568 | | |
| PRESS | 2.412E+009 | | R-Squared | 0.9450 | | |

ANOVA analysis

The value of “PNF” for the models is less than 0.05 to indicate that it is significant and desirable as it indicates that the terms in the model that have a significant effect on the response.

P-values lower than 0.01 indicates that the model is considered to be statistically significant at the 99% confidence level .

Values greater than 0.1000 indicate the model terms are not significant. Therefore, A, B, C, AB, AC and BC are significant model terms to affect the SCOD value

Model fitting

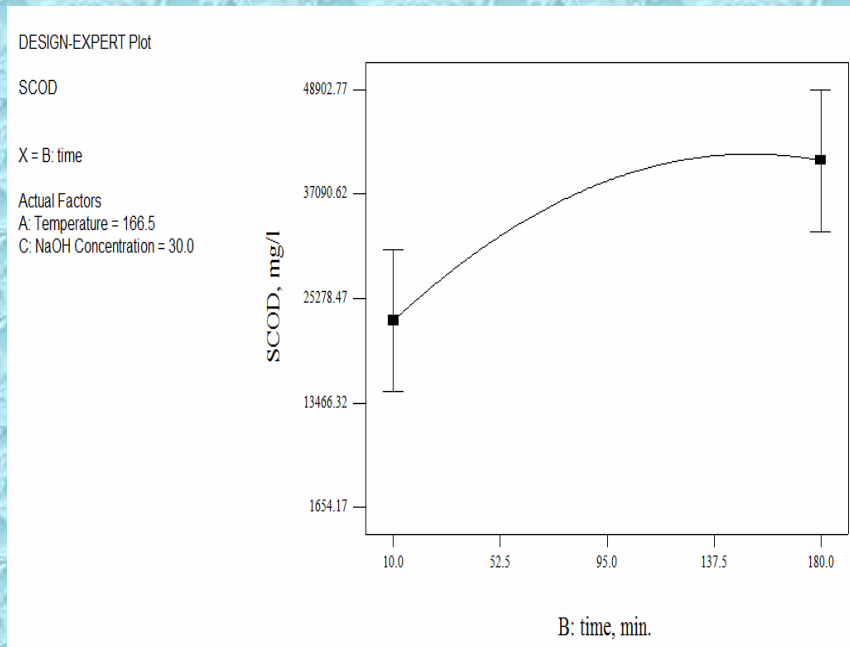
$$Y = 8217.91 + 5720.59 A + 3913.72 B + 7450.00 C - 12246.72 A^2 - 6746.72 B^2 + 20653.26 C^2 + 2689.58 AB + 5419.79 AC + 3509.38 BC$$

- The response functions are representing as the response for SCOD value, A as the coded value of variable temperature, B as the coded value of stirring time and C as the coded value of alkaline concentration

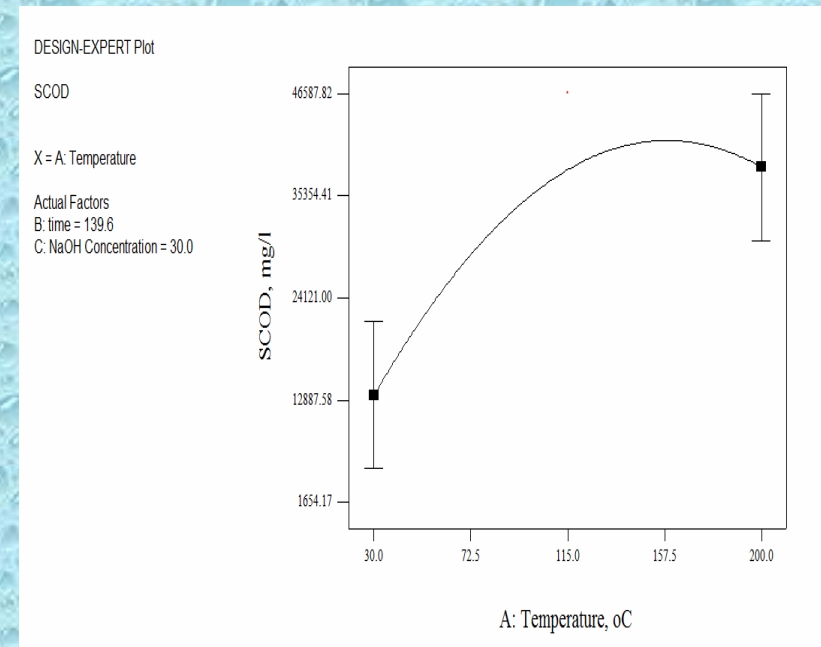


Effect of process conditions

Influence of stirring time on SCOD



Influence of temperature and stirring time on SCOD



Influence of alkaline concentration on SCOD

DESIGN-EXPERT Plot

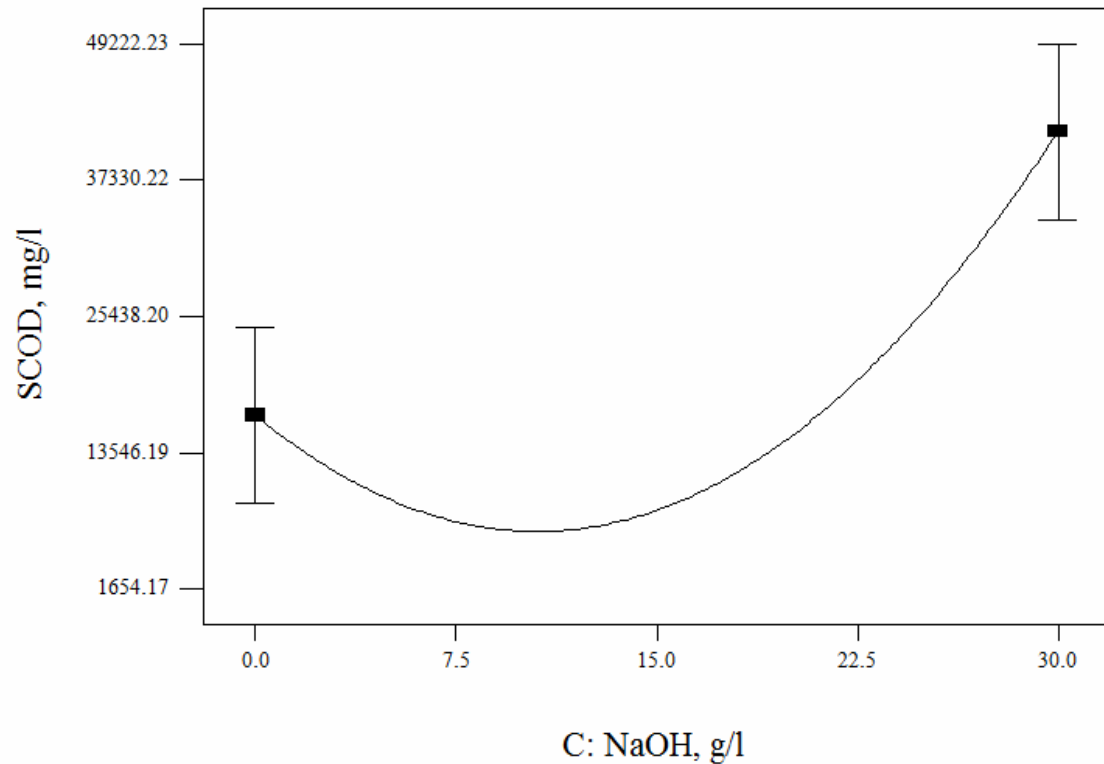
SCOD


X = C: NaOH Concentration

Actual Factors

A: Temperature = 152.6

B: time = 155.7

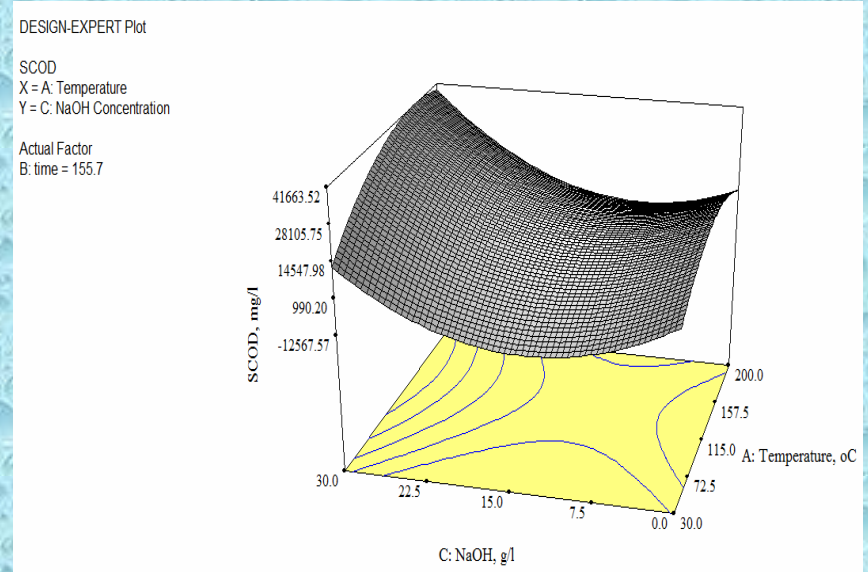
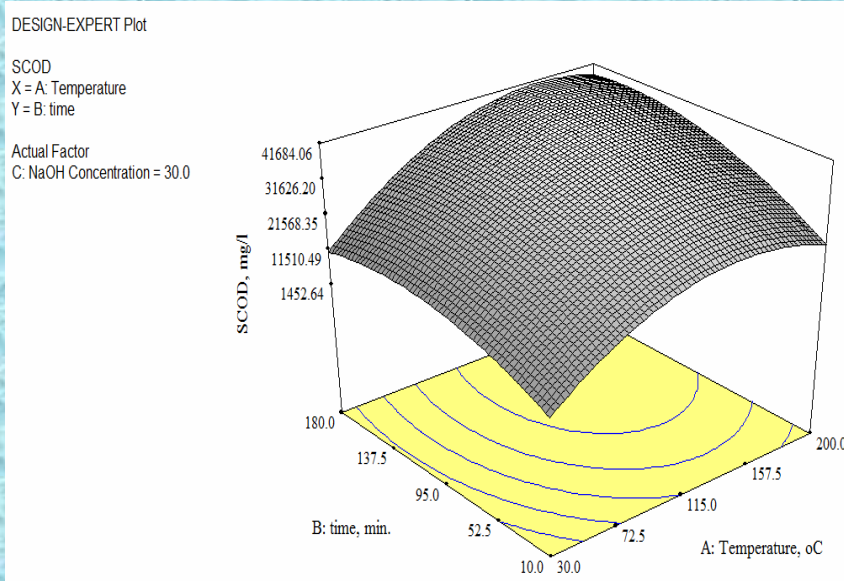




Interactions between the variables

Influence of temperature and stirring time on SCOD

Influence of NaOH concentration and stirring time on SCOD



Influence of stirring time and NaOH concentration on SCOD

By analyzing the Figure, it can be easily seen that at high NaOH concentration at fixed temperature 166.5 °C, the SCOD rises proportionally with stirring time. For example, at 30 g/l of NaOH, when the sample was subject to an alkaline thermochemical process stirring time increment of 180 min from 10 min., it consequently led to a proportional increase of SCOD to 41611.81 mg/l by approximately 17939.83 mg/l.

DESIGN-EXPERT Plot

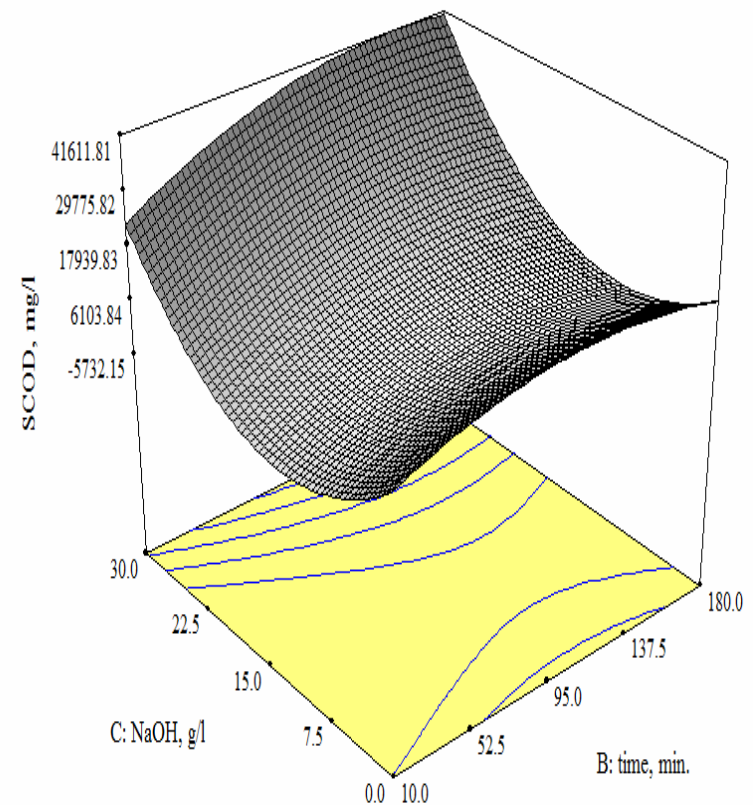
SCOD

X = B: time

Y = C: NaOH Concentration

Actual Factor

A: Temperature = 166.5



Optimum conditions for maximum SCOD production

| No. | Temperature , °C | Time, min | NaOH, g/l | SCOD, mg/l | Desirability |
|-----|------------------|-----------|-----------|------------|--------------|
| 1 | 157.6 | 133.1 | 29.9 | 41211 | 1.000 |
| 2 | 142.9 | 145.7 | 30.0 | 41204 | 1.000 |
| 3 | 166.6 | 164.2 | 30.0 | 41387 | 1.000 |
| 4 | 163.4 | 136.1 | 30.0 | 41422 | 1.000 |
| 5 | 173.8 | 142.8 | 30.0 | 41243 | 1.000 |
| 6 | 122.8 | 115.8 | 30.0 | 38712 | 0.937 |
| 7 | 116.4 | 97.8 | 0.0 | 21430 | 0.500 |
| 8 | 116.8 | 98.6 | 0.0 | 21429 | 0.500 |
| 9 | 122.8 | 108.9 | 0.0 | 21273 | 0.496 |

CONCLUSION

- A well dissolving of cellulosic compounds in rice straw is achieved by alkaline thermochemical hydrolysis.
- Alkaline thermochemical hydrolysis process leads to the increasing of transformation of non-solution complex cellulosic compounds to soluble simple compounds.
- The mathematical model developed could predict the SCOD yield at any point in the experimental domain as well as the determination of the optimal solubilization conditions with sufficient degree of accuracy
- The effect of alkaline and the thermochemical hydrolysis conditions to achieve an optimal response with 41211 mg/l of SCOD value were found to be 157.6 °C for the reaction temperature, 133.1 min for the stirring time and 29.9 g/l for the NaOH concentration.
- These results proved that alkaline thermochemical pretreatment was highly potential for increasing the SCOD value of rice straw and the use of RSM based on CCD was practical for the simultaneous study of effects by process variables on the SCOD value and the possible interaction between them
- Also from the results, a process for the production of biogas or compost from organic solid waste shall have two main stages. The two-stage design must involve alkaline pretreatment, followed by anaerobic digestion or composting process unit. In this situation the rejected and risk of water and soil resource waste will be decreased to minimum

*Thank you for your
Attention*