# Optimization of thermal-NaOH pretreatment process of green house wastes to enhance methane production

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## HIGHLIGHTS

Thermal-NaOH pretreatment process was optimized to increase methane production from green house wastes (GHW). Optimum conditions were found 0.23% NaOH concentration, 71°C reaction temperature, 1 h reaction time and 0 rpm mixing. At these conditions, increase in BMP, compared to raw GHW BMP was determined as 38%.

**Keywords:** Anaerobic digestion; Biogas; GHW; Thermal-NaOH pretreatment; Proses optimization

## INTRODUCTION

Increased concern for the security of oil supplies and the negative impact of fossil fuels on the environment has put pressure on society to find renewable alternatives (Midilli et al., 2006). Consequently, there is a growing interest in ecologically sustainable biofuels such as biodiesel, bioethanol, biohydrogen and biogas. Of these biofuels, biogas can be produced from lignocellulosic residues such as agricultural residues and forestry wastes (Us and Perendeci, 2012). Since lignocelluloses are extremely resistant to enzymatic conversion, there has been an intense research on the development of pretreatment technologies.

The conventional disposal methods of GHW such as unconfined storage in road edges, landfilling and uncontrolled burning cause significant environmental problems in Antalya-Turkey. Wastes disposed from GH, are renewable and cost free lignocellulosic residues, lacking of alternative uses, whose management is necessary to prevent environmental pollution and gain alternative utilization as a fuel biogas. In this study, thermal-NaOH pretreatment process was evaluated to increase methane production from GHW.

## MATERIALS AND METHODS

Combined thermal-NaOH pretreatment of GHW has been evaluated by the effects of selected independent variables on dependent variables. The independent variables determined as reaction temperature (60-100°C), reaction time (1-4 hour), NaOH concentration (0-10%) and mixing speed (0-500 rpm). Initial solid content of the GHW was fixed to 5% in the pretreatment experiments. Dependent variables were sReducing sugar and Biochemical Methane Potential (BMP). For the determination of the effect of independent variables on dependent variables, central composite design (CCD) method of response surface method (RSM) has been used. Design expert, trial version 8.0. (Stat – Ease Inc., Minneapolis, USA) was used for CCD and statistical analysis of the experimental data. Suggested CCD thermal-NaOH pretreatment experiments were conducted in 1 L laboratory scale glass reactors immersed in an oil heating bath equipped with a reflux condenser. All pretreatment experiments were performed in duplicates. Methane productions from raw and pretreated GHW samples were carried out by batch BMP test (Carrere et al., 2009). Total sReducing sugar as glucose were determined by the DNS method (Miller, 1959). sReducing sugar and BMP values were used to develop regression models. The validity of these models has been tested by analysis of variance (ANOVA), p- and F- values. Combined thermal-NaOH pretreatment process of GHW was optimized.

## RESULTS AND DISCUSSION

### Effect of thermal-NaOH pretreatment on sRedSugar and BMP

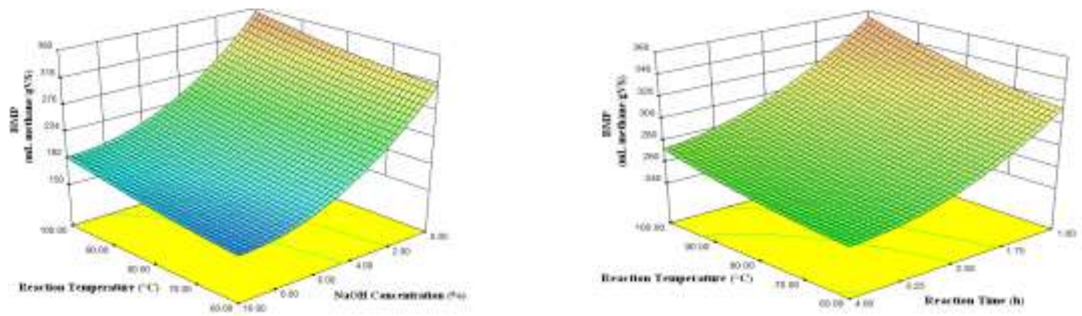
The highest sRedSugar concentration was found as 334.8 mgGlucose/gVS from the GHW pretreated at 0% NaOH concentration, 100°C reaction temperature, 4 hours reaction time and no mixing. On the other hand, the lowest sRedSugar concentration was measured as 17.66 mgGlucose/gVS at 10% NaOH concentration, 100°C reaction temperature, 4 hours reaction time and 500 rpm mixing speed. While, highest BMP amount of 359.80 mL$CH_4$/gVS was measured from the GHW pretreated under 0% NaOH concentration, 100°C reaction temperature, 1 hour reaction time and without mixing, the lowest BMP value (120.62 mL$CH_4$/gVS) was obtained from the GHW pretreated under the 10% NaOH concentration, 100°C reaction temperature, 4 hours reaction time and no mixing conditions. It was observed that higher NaOH concentration in pretreatment resulted in lower reducing sugar and BMP yield.

### Optimization of thermal-NaOH pretreatment conditions for BMP

Quadratic regression model for BMP was highly significant, as it is evident from the Fisher's F-test with very low probability value (P model>F=0.0001). The quality of the fit of polynomial model was expressed by the coefficient determination ($R^2$) and adjusted determination of coefficient (Adj-$R^2$). $R^2$ and Adj-$R^2$ were calculated as 0.9083 and 0.8753 for BMP model, indicating a high degree of correlation between the response and the independent variables. Reaction temperature, reaction time, mixing speed and NaOH concentration were significant for BMP model (Figure 1).

The experimental outcomes were optimized by Design-Expert® software using the approximating function of BMP. During the optimization, a cost driven approach and production of maximum BMP was preferred. Reaction temperature, reaction time and NaOH concentration was minimized and mixing speed was kept in the ranges for maximized BMP. Optimum conditions were obtained with the desirability of 0.689 at 0.23% NaOH concentration, 71°C reaction temperature, 1 h reaction time and 0 rpm mixing. Under these conditions 315.1 mL$CH_4$/gVS was predicted for BMP. In order to validate the optimization, a specific batch run was performed under these optimum conditions. In this run, 299.1 mL$CH_4$/gVS was realized for BMP. Error between estimated results and experimental ones was calculated as 5.07% for BMP model. Results from specific validation experiment supported the predictive power of the BMP model. Increase in BMP compared to raw GHW BMP was determined as 38%.

**Figure 1.** 3D response surface plots: effects of temperature and NaOH concentration on BMP (a), effects of temperature and reaction time on BMP (b)



(a) (b)

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