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Qualitative and quantitative analysis of biogas generated from co-digestion of cow dung, municipal sewage and kitchen waste

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Introduction

As reported by Sabetghadam (2005), 53.4, 36.3, 1.1, 8.9, and 0.2% of total energy consumption in Iran consisted of oil products, natural gas, coal, electricity energy, and modern energy sources, respectively. The modern energies included solar, biomass, wind and nuclear. The energy mix has been evolving towards clean energies. From 1966–2005, the contribution of natural gas increased from 1.3% to 36.3% and the contribution of electricity was doubled from 4.1% to 8.9%. The share of oil products in domestic consumption has dropped from 84.3% to 53.4%.

Iran has abundant renewable energy resources, including solar energy, wind power, geothermal energy, and biomass, as well as the ability to manufacture the relatively labor-intensive systems that harness these. By developing such energy sources developing countries can reduce their dependence on oil and natural gas, creating energy portfolios that are less vulnerable to price rises. In many circumstances, these investments can be less expensive than fossil fuel energy systems. Over the past ten years some researches on solar and biomass energy have resulted in development and the establishment of a few small- and medium-scale electricity generation plants, powered via solar and biomass energy. There has also been the development of digesters to increase biogas production. Renewable energy is new to Iran and there is a long way to go. Except for the few afore mentioned projects, small-scale technologies to bring power to remote villages have a better chance of being adopted than those implemented at the national level.

Materials and Methods

In this research the amount of generated methane (methane content of biogas %) from co-digestion of municipal sewage, kitchen waste, and cow dung was measured in 7 different combinations (treatment). Two important parameters affecting methane production such as volatile solid (VS) and total solid (TS) were measured according to *Method 1684* and *CEN/TS 15148*. Furthermore some environmental conditions such as temperature, pH, EC and some of the most important elements of desired substrate such as amount of C, N, P, K, and SO_4^{2-} were determined. pH using pH-meter and EC using EC-meter, C using titration method according to Rongping *et al.* (2010) and N using Kjeldahl apparatus, P using Spectrophotometer, K using Flame photometer, and SO_4^{2-} using weighting were determined according to Standard Method for the Examination of Water and Wastewater.

Methane (CH_4) was determined using a multi-function gas detector brand GMI Ltd model GT-42. Its detection ranges were 0–10000 ppm (parts per million), 0–100 % LEL (lower explosive limit), and 0–100 % VOL (volume) in temperature limit -20–50 °C and 0–95% R.H (relative humidity).

Results and Discussion

The mean amount of methane contents of biogas during the co-digestion of the substrates for all 7 treatments reported in table 1 were 4363.25, 875.13, 169.13, 3424.38, 2911.88, 2714.38, and 193.5 ppm, respectively. Methane contents obtained from municipal waste was the highest among the substrates and after that the combination of 1:1:1 of the substrates was more than the others. The methane content was low in the first seven days of digestion, and thereafter rapidly increased over 85% within 22 days. Totally the highest methane contents of treatments were during 30–35 days of digestion which was agreed with other researches. This can be shown in Fig. 5 that the highest methane content was 10000 ppm and appertain to treatment 1.

The results showed that TS and VS of kitchen waste were lower than the other substrates. These findings

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agreed with Chen *et al.* (2010) researches in which had been reported the commercial kitchen waste has lower TS and VS contents, possibly because the commercial kitchen waste stream contains food with higher moisture contents such as fruits. Furthermore it can be shown that after digestion, the amount of TS of municipal waste, cow manure, and kitchen waste decreased 46, 57, and 46% respectively, while amount of VS of these substrates decreased 82, 92, and 85%, respectively. The results were similar to Chen *et al.* (2010) results. They reported that between 58 and 99% of the VS were degraded to methane and carbon dioxide under most feed concentrations. The obtained methane significantly correlated with VS, TS at level of 5 %. The pH of the substrate nearly was constant during the digestion. The results showed that the treatments with more municipal waste had more VS and TS while the treatments with more cow dung had more C/N.

Some mathematical models were made between the properties and generated methane. The best empirical model which can estimate amount of generated methane using the properties was a polynomial function. The function coefficients were determined for each parameter by normalizing them. Finally the results show that the model made using difference of VS and TS before and after of digestion had the most accuracy among the models (R^2=0.897, RMSE=630, SSE=4.76e+06).

Conclusions

The results of conducted methane fermentation study on physico-chemical properties of substrates including municipal waste, kitchen waste and cow dung reviled that VS, TS, C/N, P, K, and SO_4^{2-} affect biogas and methane production. However the correlation between methane contents with VS and TS was more than the other properties and the methane estimation models made using the VS and TS was more accurate than the other models.

Keywords: Anaerobic digestion, Material combination, Methane, Total solid, Volatile solid